DOCUMENT RESUME

ED 046 628 RE 003 196

AUTHOR	Gammon, Elizabeth Macken
TITLE	A Syntactical Analysis of Some First-Grade Readers.
INSTITUTION	Stanford Univ., Calif. Inst. for Mathematical Studies in Social Science.
REPORT NO	TR-155
PUB DATE	22 Jun 70
NOTE	171p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$6.58
DESCRIPTORS	*Basic Reading, Beginning Reading, Grade 1, *Grammar, Linguistics, Phrase Structure, *Reading Materials, *Structural Analysis, Structural Grammar, *Syntax

ABSTRACT

Two widely used first-grade reading series, Ginn and Scott-Foresman, were analyzed in terms of six phrase-structure grammars in an attempt to discover frequencies for sentence types. The six grammars were noun phrase, verb phrase, verbal modifier, statements without verbs, interrogative, and statements with verbs. Categorial grammars were written for comparison with noun-phrase and verb-phrase grammars. A quantitative method for evaluating linguistic grammars, developed from the analyses, provided a theoretical framework for accounting for various kinds of utterances. Chi-square analysis showed the grammars to be well-suited to both series, with the verbal modifier and statements without verbs providing the best fits. The categorial grammars were approximately equivalent to the phrase-structure grammars, making them possibly more useful for further study since they require fewer manipulations of the text. It was concluded that the method developed would be useful in further analysis of reading materials. Such analysis would be important in increasing the similarity of sentence structure in materials to that of children's speech. Tables and a bibliography are included. (MS)

ED0 46628

A SYNTACTICAL ANALYSIS OF SOME FIRST-GRADE READERS

BY

ELIZABETH MACKEN GAMMON

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June 22, 1970

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Elizabeth Macken Gammon

TECHNICAL REPORT NO. 155

June 22, 1970

PSYCHOLOGY SERIES

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Table of Contents

Chapter Page

I. Rationale and Overview 1

II. Preliminary Steps of Analysis 7

III. Phrase-Structure Grammars 21

- Noun-Phrase Grammar
- Verb-Phrase Grammar
- Grammar for Verbal Modifiers
- Grammar for Statements without Verbs
- Grammar for Interrogatives
- Compound Statements
- Grammar for Statements with Verbs

IV. Categorial Grammars 128

- Categorial Grammar for Noun Phrases
- Categorial Grammar for Verb Phrases

V. Summary and Conclusions 159

References 163

A SYNTACTICAL ANALYSIS OF SOME FIRST-GRADE READERS*

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CHAPTER I

RATIONALE AND OVERVIEW

An important problem at all levels of instruction is the appropriate matching of reading materials to the reader. "Appropriate matching" refers to the reader's ability to comprehend the materials and to the effectiveness of the materials in furthering some of the aims of the educational process; the term "reading materials" includes both materials which teach children to read and materials which convey other information. In the past the appropriateness of materials has been discussed in relation to their content, their format and organization, and their difficulty level as expressed by their vocabulary load, their sentence structure, and their level of human interest. (Chall, 1958) In the revision of primary readers, in particular, the concern has been with finding the appropriate level of difficulty as measured by the frequency of new vocabulary words and the number of repetitions of a new word. (Becker, 1936; Gates, 1930; Hockett, 1938; Mehl, 1931; Spache, 1941) But for primary readers two other conceptions of "appropriateness" are important: 1) How does the sentence structure found in the readers compare to the sentence structure of the child's speech? and 2) How does the sentence structure found in the readers compare to that of correct adult speech which is one of the aims of education?

Evidence for the importance of the first new conception of appropriateness, the similarity of the readers to oral speech, comes from four studies: Bormuth (1964), Ruddell (1964, 1965), and Strickland (1962). Strickland conducted an extensive analysis of the patterns of sentence structure in the

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*The work reported here has been supported by the National Science Foundation (Grant G-18709), Office of Education Contract OEC-4-6-061493-2089 and the Ravenswood Subcontract to Stanford under Office of Education Grant OEG 0041.

oral language of children in the first six grades of elementary school, and a partial analysis of the sentence structure of second- and sixth-grade readers. The purpose of the reader analysis was to determine whether the common speech patterns of children appeared in the readers; no effort was made to determine and compare the frequency of the patterns. Strickland found that many of the patterns most frequently used by children appeared in the readers, but that the patterns appeared in a somewhat random manner and that there appeared to be no scheme for development of control over sentence structure which paralleled the generally accepted scheme for the development of control over vocabulary. Strickland also found direct relationships between the development of a child's oral language ability and his general reading ability, as measured by a variety of tests. Ruddell (1965) studied the relationship of selected language variables to reading achievement, and concluded that a child's control over designated aspects of his morphological and syntactical language is significantly related to his reading ability as measured by paragraph meaning, sentence meaning, and vocabulary achievement scores. The Strickland study and the Ruddell (1965) study indicate a relation between stage of oral language development and reading ability; in the following studies by Bormuth (1964) and Ruddell (1964), the relationships between reading achievement and the similarity of reading material to the reader's oral language were explored. Bormuth used Strickland's findings to rate reading passages according to their similarity to children's speech. He found that this index was related to comprehension difficulty at low levels of reading achievement; that is, for children who have reading difficulties an increased similarity of the language in the reading material to their own language patterns increased comprehension. This relationship was not strong enough to be significant, but in establishing his similarity index Bormuth used only the first level of Strickland's analysis which ignored many of the substructures of language, and in addition used her combined oral speech data for first, third, and sixth graders while his subjects were fourth to eighth graders. If the similarity index had been based on more details of the language pattern and had been changed for each grade level to include the particular speech patterns of that level, the relationship would probably have been stronger. Ruddell (1964) incorporated these ideas. He constructed six reading passages using the language patterns which Strickland found to occur in the oral language of fourth graders; the patterns were used in the reading passages in the same proportional frequency in which they occurred in the oral language. Three of the reading passages included only high frequency patterns and three included only low frequency patterns. His subjects were fourth graders from the identical school from which Strickland obtained her oral language sample. Ruddell found that comprehension scores on the written material designed with high frequency patterns of oral language structure and comprehension scores on written material designed with low frequency patterns of oral language structure were significantly different beyond the .01 level in the expected direction.

These studies indicate a definite relationship between reading ease and the similarity of written material to the reader's spoken language, and suggest the importance of a further understanding of this relationship. For children who are having difficulties in learning to read, perhaps the best kind of remedial materials would be those which use only patterns of sentence structure which the child himself uses. Then only the act of reading and not the structure and sound of the material would be new to the students.

The second concept of "appropriateness", the similarity of the readers to correct adult speech, concerns additional goals of the primary reading program. Once the basic mechanics of reading have been established through material incorporating only the child's language patterns, sentence patterns which are more complicated and more like those of adult speech could be introduced. Expanding the sentence structures of the readers in some systematic way would familiarize the child with adult speech and presumably develop his own oral language patterns.

Much further study is obviously required to explore these ideas, but certainly a first step is a complete analysis of the sentence patterns in reading material presently being used. Strickland's analysis was partial in that she surveyed only parts of the readers and was interested only in the presence or absence of sentence types but not their frequencies of occurrence. Ruddell's (1964) study indicates the need for consideration of type frequency in determining similarity. A concise and complete representation of sentence patterns and their relative frequencies in grade school readers is needed to begin further work in comparisons of oral language patterns, reading material, and reading ability.

This suggests the linguists' approach to syntactical analyses through the construction of representative grammars. Several types of grammars are possible, for example, phrase-structure grammars, categorial grammars, and case grammars. And within each of these, a great number of versions could be written. The problem of finding the similarity of the sentence patterns in the readers to the sentence patterns of the child's speech requires not merely a grammar, but the best grammar in the sense that it most accurately represents the utterances in the corpus and their frequencies of occurrence. The problem of evaluating several grammars written for the same corpus has not been adequately solved. Traditional criteria for a "good" grammar are: the grammar generates all of the grammatical sentences and none of the ungrammatical ones, the grammar is in some sense simple, and the grammar is finite. (Chomsky, 1957) A grammar which satisfies these criteria but is clearly unsatisfactory is the following:

> Let N be the number of utterances in the corpus, and let a_1, a_2, ..., a_N be the utterances. Let the generative rules of the grammar be:

$$\begin{array}{l} S \rightarrow a_1 \\ S \rightarrow a_2 \\ \vdots \\ S \rightarrow a_N \end{array}$$

A split-half analysis, in which the rules which generate perfectly one half of the corpus (the even numbered utterances, for example) are applied to the other half, would obviously show a poor fit. Quantitative methods for evaluating grammars are needed, not only for the analysis of primary readers, but for all applications of psycholinguistics.

This dissertation will make contributions to both areas outlined above. It will furnish a thorough syntactical analysis for some primary readers, and it will demonstrate a quantitative method for evaluating grammars written for a specific corpus. (Suppes, 1970)

The primary purpose of this study is to provide a syntactical analysis of two widely used first-grade readers, the Scott-Foresman series[1] and the Ginn series.[1] A phrase-structure grammar will be written for the entire corpus and a categorial grammar will be written for certain aspects of the corpus for purposes of comparison. The phrase-structure grammar is the more natural in that it uses terminology and constructions familiar from the study of Latin grammar; however, the categorial grammar has the advantage of being more easily adapted to other corpuses.

The study will demonstrate a quantitative method of evaluating grammars which provides a theoretical framework to account for the utterances and their frequencies of occurrence. A preview of the method will be given here, and complete details will be presented in the following chapters. The first step in the analysis is to obtain an overview of the syntactic types which appear in the corpus. This is done by coding each utterance as an ordered n-tuple consisting of the part of speech of each word in the order of occurrence. The part of speech is determined according to rules commonly used for English grammars; possible categories are: noun, transitive verb, intransitive verb, adverb, adjective, etc. The sentence, "Come and see the new hat.", would be coded as (IV+C+TV+T+A+N) where "IV" stands for intransitive verb, "C" stands for conjunction, "TV" stands for transitive verb, "T" stands for article, "A" stands for adjective, and "N" stands for noun. The observed frequency of each syntactical type is then determined.

A grammar is written which generates these types, and the quantitative evaluation of the grammar begins with the assignment of parameters to each of the choice points. For an example of "choice point" consider the following rewrite rule of a generative grammar: $S \rightarrow G+TV+(T)+(\left\{\begin{matrix}A\\A+A\end{matrix}\right\})+N$, where "G" stands for proper noun, and the other letters are as defined above. The parentheses indicate that the contents may be deleted, and the brackets indicate that only one of the members may be used. The choices of this rewrite rule are: to include or delete the article, and to use zero, one, or two adjectives. These are referred to as "choice points", and each is assigned a parameter denoting the probability of that choice.

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[1] These texts are listed in the references according to the authors: Ousley and Russell (1957, 1961), Robinson, Monroe, and Artley (1962a, 1962b, 1962c, 1962d), and Russell and Ousley (1957). Throughout this paper these texts will be referred to by their reading level and publisher; this is the clearest and most widely used procedure.

The parameters can then be used to state the theoretical probability of any syntactical type derivable from the grammar. The probability of type (G+TV+T+A+N), as in "Tom hit the red ball.", is the probability of choosing "T" times the probability of choosing "A" times the probability of Selecting the particular rewrite rule given above if more than one is allowed by the grammar. If optional transformations are included in the grammar, parameters must be assigned to the options and must be incorporated into the theoretical probabilities. Obligatory transformations require no parameters.

Using the theoretical probabilities and the observed type frequencies, the parameters can be estimated using the method of maximum-likelihood. This method is workable as long as the grammar is unambiguous; that is, as long as each syntactical type can be generated in only one way. If more than one derivation is possible for a syntactical type, the theoretical probability of that type consists of a sum of products and the maximum-likelihood calculations are extremely difficult.

Once the parameters have been estimated, the estimated frequencies of each syntactical type can be calculated. Chi-square tests can then be used to determine the goodness-of-fit of the model (the grammar) to the observed frequencies of the syntactical types.

Chapter II will give the details of all steps in the analysis preceeding the construction of the final grammars; Chapter III will present the phrase-structure grammars and their statistical analyses; Chapter IV will present the categorial grammars and their analyses; and Chapter V contains a summary and some concluding comments.

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CHAPTER II

PRELIMINARY STEPS OF ANALYSIS

The corpus for this study is the Ginn first-grade reading series and the Scott-Foresman first-grade reading series. These texts are widely used and appeared to be similar in terms of format, content, and sentence structure. The hope was that the data from the two series would combine to form large frequencies for all sentence types; although, as will be seen later, this did not prove to be precisely the case. Each first grade series is divided into a set of pre-primers, a set of primers, and a set of first readers which are read by all students; all of these have been included in the analysis. Optional texts such as the Scott-Foresman Guess Who for slower learners were not analyzed.

The texts are divided into short stories consisting mainly of conversations between persons or animals, so many sentences contain an identification of the speaker. Typical examples are: ""I like this kitten," said Betty." and "Susan said, "Toy Mouse wants a ride."" Neither the titles of the stories nor the speaker identifiers (Betty said, he said, etc.) were included in the analysis. The titles consisted mainly of short noun phrases and were clearly not indicative of the grammar used for sentences within the stories. Speaker identifiers, too, had a structure of their own, and it seemed appropriate to consider them merely as labels. To consider "Susan said, "Toy Mouse wants a ride."" as the sentence for analysis rather than simply "Toy Mouse wants a ride." would distinguish sentence types in a way which would not emphasize the most interesting characteristics of the grammar. In that case, "Susan said, "Toy Mouse wants a ride."", ""Toy Mouse wants a ride," said Susan.", and ""Toy Mouse, said Susan, "wants a ride."" would have to be considered as separate sentence types; while this is a meaningful distinction, it was not considered essential for a first syntactical analysis.

Structures which were included in the analysis will from here on be called "utterances". An utterance is a string of words which begins with a capital letter and ends with one of the following terminal punctuation marks: ".", "?", "!", or a "," followed by a speaker identifier and a ".". (The symbol "." used to indicate abbreviations was not considered terminal.) Speaker identifiers found at the beginning or the middle of an utterance were ignored, and all punctuation was ignored except for the purpose of distinguishing utterances. Thus, the sentence, ""I want it," said Bill, "but I can't eat it."" includes one utterance: "I want it but I can't eat it"; whereas the sentences, ""I want it," said Bill. "But I can't eat it."" include two utterances: "I want it" and "But I can't eat it".

All of the utterances in both first-grade reading series were included in the analysis. The number of utterances in each text is shown in Table 1.

Insert Table 1 about here

The table indicates that the number of utterances in each division were roughly the same for each series, although the number of utterances in the Ginn series was consistently greater.

The first step in the analysis was the coding of each utterance according to type. Each utterance was coded as an ordered n-tuple consisting of the part of speech of each word in the order of occurrence. The part of speech was determined according to rules commonly used for English grammars. Table 2 lists all parts of speech found in the corpus along with the abbreviations used in coding (and throughout this paper), typical examples, and examples of any phrases of two or more words which were considered to be a unit and coded as only one part of speech.

Insert Table 2 about here

[illegible]00013

TABLE 1

Utterance Count

Text	Pre-Primer	Primer	Reader	Total
Ginn	858	1343	1925	4126
Scott-Foresman	638	1040	1450	3128
Totals	1496	2383	3375	7254

TABLE 2

Parts of Speech in Corpus

Part of Speech	Abbreviation	Example	Examples of Types Containing more than 1 Word
adjective	A	pretty	
adverb	ADV	fast	
article	T	the	
common noun	N	house	ice cream
conjunction	C	and	
copulative verb	CV	is	
interjection	I	oh	
interrogative adjective	IADJ	which	
interrogative adverb	IADV	how	
interrogative pronoun, objective case	IP(2)	whom	
interrogative pronoun, subjective case	IP(1)	who	
intransitive verb	IV	go	
locative	L	here	
modal	M	can	
negation	-	not	
number used in counting	NBR	one	
preposition	J	into	
pronoun, objective case	P(2)	him	
pronoun, subjective case	P(1)	he	
proper noun	G	Betty	Mr. Green, Frisky Kitten
rejoinder	R	yes	all right, thank you
relative pronoun, objective case	RP(2)	whom	
relative pronoun, subjective case	RP(1)	who	
salutation	S	hello	Good day, Happy birthday
sound	Z	zoom	
subordinate conjunction	CON	that	
"to" used with infinitives	O	to	
transitive verb	TV	want	

Clearly a given word could be assigned to different parts of speech depending on its usage in a particular utterance. In "I saw the boy who hit Mary." "who" is a relative pronoun, whereas in "Who is he?" "who" is an interrogative pronoun. Similarly the coding of phrases such as "Frisky Kitten" depended on usage. The phrase, "Frisky Kitten" was usually used as the name of a cat in which case the phrase was coded as a proper noun (G, not G+G); however, in the sentence, "My pet is a frisky kitten." "Frisky Kitten" would be coded as an adjective followed by a common noun. Table 3 shows some coded types to illustrate the coding method.

Insert Table 3 about here

A word must be said about the classification of verbs. Verbs were put into one of three categories according to their position in the utterance. Verbs which stood between two noun phrases were labeled transitive verbs; verbs which were preceded but not followed by a noun phrase were labeled intransitive verbs, and verbs which were preceded by a noun phrase and followed by an adjective phrase were labeled copulative verbs. (Nouns used as adverbs as in "He goes home." were classified as such so that in this sentence "goes" is intransitive.) Under this classification "to be" verbs can be in any of the three classifications depending on usage; the verb is transitive in "He is a very good boy.", intransitive in "Sally is here with me.", and copulative in "Your new dress is very pretty." If "to be" verbs had been placed in a category of their own as is often done, a fourth category would have been required for verbs such as "look" and "get" in "She looks beautiful." and "She is getting more beautiful every day." As will be seen, a problem of too many types and small frequencies within types was already present and to add a fourth category for verbs would only increase this problem.

The utterances were then sorted according to type. This original classification scheme produced a very large number of types with relatively small frequencies of occurrence as is illustrated in Tables 4 and 5.

Insert Tables 4 and 5 about here

TABLE 3

Frequently Occurring Utterance Types

Coded Type	Examples
(IV+L+K)	Come here, Betty.
(P(1)+TV+T+A+N)	I like the little chairs.
(IV+J+P(2))	Look at him.
(IV+C+TV+G)	Come and see Susan.
(P(1)+M+IV)	I can paint.
(K)	Betty!
(G+CV+A)	Jane is pretty.
(Z)	Bow-wow.
(I+K)	Oh, Dick!
(L+P(1)+IV)	Here I come.

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TABLE 4

Statistics for Utterance Types under Original Classification

Text	Total Number of Types	% of Types with Frequency > 5	% of Types with Frequency > 1
Ginn Pre-Primer	250	10.4	45.2
Scott-Foresman Pre-Primer	277	8.3	28.9
Pre-Primers Combined	454	10.1	39.9
Ginn Primer	664	5.0	28.8
Scott-Foresman Primer	666	3.3	19.1
Primers Combined	1185	4.6	26.3
Ginn Reader	1099	3.3	25.8
Scott-Foresman Reader	1096	1.6	12.8
Readers Combined	2015	2.9	21.3

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TABLE 5

Distribution of Utterance Types under Original Classification

	Number of Types with Stated Frequency Range		
Frequency	**Pre-Primers Combined**	**Primers Combined**	**Readers Combined**
131-140	1	0	0
121-130	0	0	0
111-120	0	0	0
101-110	0	1	0
91-100	0	0	1
81-90	1	0	0
71-80	0	0	0
61-70	0	0	1
51-60	0	0	0
41-50	1	0	1
31-40	0	2	1
21-30	6	7	4
11-20	16	20	15
1-10	429	1155	1992

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Table 4 shows that contrary to expectation the Ginn and Scott-Foresman series do not in general contain the same utterance types. The Ginn reader, for example, contains 1099 utterance types and the Scott-Foresman reader contains 1096 types; thus if the readers had no types in common, the readers combined would contain 2195 types. In fact, the readers combined contain 2015 types indicating that only 180 or about 16% of the utterance types in each reader are common to both readers. Further study indicates that the types common to both readers are those with the greatest frequencies in the individual readers, and that the types with small frequencies in one reader do not usually find a match in the other reader.

It is interesting to note that the number of utterance types in each section of each series is nearly the same; the number of types in the two pre-primers differs by 27 and the number of types in the primers and readers differs by 2 and 3 respectively. In each case the Scott-Foresman series contains the greater number of utterances types which was unexpected because the Ginn series contains the greater number of utterances. (Table 1)

To construct a grammar for the corpus and apply the chi-square statistic as indicated in Chapter I (this use of the chi-square will be presented in detail in Chapter III), a smaller number of utterance types is desirable and greater frequencies within types is required. Elimination of all types with frequency less than or equal to five, for example, was not feasible at this point because only a small percent of the corpus would then be described by the grammar (55.5% of the pre-primers combined, 33.5% of the primers combined, and 24.3% of the readers combined). In order to obtain a smaller number of types and greater frequencies within types, a method for meaningfully collapsing the types was developed. This involved the combining of certain groups of letters (parts of speech) into one category whenever they occurred. One grammar would then be written to represent each set of rules for combination, and another grammar would be written for the utterance types containing the collapsed categories.

The first attempt involved the use of noun phrases and verb phrases. Pronouns and strings of articles, adjectives, and nouns were replaced by "NP" for "noun phrase", and strings of modals, negatives, and verbs were replaced by "VP" for "verb phrase." For example the sentences, "Betty does not want the pretty red ball," of type (G+M+-+TV+T+A+A+N) and "That puppy likes me." of type (A+N+TV+P(2)) would both be of type (NP+VP+NP) under noun-phrase and verb-phrase collapsing. As Table 6 shows, this made a substantial reduction in the number of types, but a large number of types with low frequencies remained.

Insert Table 6 about here

The final collapsing involves the use of a category called "verbal modifiers" (VM) as well as noun phrases and verb phrases. In the verbal modifier category are strings of adverbs, prepositional phrases, locatives, and noun phrases used as adverbs. The utterances, "He runs fast." (P(1)+IV+ADV), "He runs very fast." (P(1)+IV+ADV+ADV), and "He runs to the house." (P(1)+IV+J+T+N), would all be of type (NP+VP+VM) under the final collapsing. Complete details of the noun-phrase, verb-phrase, and verbal-modifier classification systems will be given in Chpater III when the phrase-structure grammars are presented.

As Table 6 shows, this final collapsing greatly reduced the number of types compared to the first two classification systems. While the percent of types with frequencies greater than five remains low, the percent of the corpus which can now be accounted for by types with frequencies greater than five has substantially increased. Eighty-four percent of the corpus can now be described by types with frequency greater than five.

Tables 7 and 8 show further details of the number and frequencies of types which have been formed using the noun-phrase, verb-phrase, and verbal-modifier categories.

Insert Tables 7 and 8 about here

Table 7 indicates that in general the trends apparent under the original classification system (Table 4) have continued. Each section of the Scott-Foresman series contains a greater number of types but a smaller percent of types with frequency greater than five (and greater than 1) than the corresponding Ginn section. This implies that the Scott-Foresman books contain a greater variety of sentence types than the Ginn books and in this sense are more difficult. The total number of types for the

TABLE 6

Comparison of Collapses

ection of orpus	Original No. of Types	% of Types with Freq. > 5	% of Types with Freq. > 1	Noun Phrase and Verb Phrase Collapsing No. of Types	% of Types with Freq. > 5	% of Types with Freq. > 1	Final No. of Types	% of Types with Freq. > 5	% of Types with Freq. > 1
e-Primers Combined	454	10.1	39.9	218	21.1	52.8	153	24.2	57.5
imers Combined	1185	4.6	26.3	528	15.5	42.2	364	17.3	46.2
aders Combined	2015	2.9	21.3	996	9.8	32.0	689	11.6	35.3

TABLE 7

Statistics for Utterance Types under Final Classification

Text	Total Number of Types	% of Types with Frequency > 5	% of Types with Frequency > 1
Ginn Pre-Primer	90	30.0	56.7
Scott-Foresman Pre-Primer	116	16.4	54.3
Pre-Primers Combined	153	24.2	57.5
Ginn Primer	204	23.5	49.0
Scott-Foresman Primer	262	12.6	40.5
Primers Combined	364	17.3	46.2
Ginn Reader	325	14.8	44.3
Scott-Foresman Reader	511	9.2	28.2
Readers Combined	689	11.6	35.3
All Combined	882	14.7	42.0

TABLE 8

Distribution of Utterance Types under Final Classification

Frequency	Pre-Primers Combined	Primers Combined	Readers Combined	All Combined
621-630	0	0	0	1
⋮				
561-570	0	0	0	1
⋮				
341-350	0	0	0	1
⋮				
311-320	0	0	1	0
301-310	0	0	0	1
⋮				
251-260	0	0	1	0
241-250	0	0	0	1
231-240	0	1	0	0
⋮				
211-220	0	0	0	1
⋮				
191-200	0	0	0	0
181-190	0	0	1	0
171-180	0	1	0	1
161-170	0	0	0	2
151-160	0	0	0	1
141-150	1	0	0	1
131-140	1	0	0	2
121-130	0	0	1	2
111-120	0	0	0	0
101-110	0	2	0	2
91-100	1	1	1	2
81-90	2	0	1	1
71-80	2	2	1	1
61-70	0	1	3	2
51-60	1	1	3	1
41-50	2	3	2	3
31-40	2	7	8	10
21-30	6	5	3	16
11-20	9	20	19	29
1-10	126	320	644	800

combined sections still indicates a large number of types present in only one reader, but the percent of common types is now much greater than in the previous classification systems. Again, it is generally the small frequency types which are present in only one series.

CHAPTER III

PHRASE-STRUCTURE GRAMMARS

In this chapter the phrase-structure grammars and their corresponding statistical analyses will be presented. Basically, a phrase-structure grammar is concerned with the division of sentences into their constituent parts--into phrases, subphrases, and finally into word categories. It consists of a set of rewrite rules from which, ideally, all of the grammatical types and none of the ungrammatical types can be generated.

For this corpus separate grammars have been written for the noun phrases, the verb phrases, and the verbal modifiers, and these specific grammars have been utilized in the grammar for the complete utterances. The grammar for utterances will generate such types as (NP+VP+NP), but will not generate such types as (T+A+N+TV+A+A+N). To generate a form of the latter type, first the utterance grammar, and then the noun-phrase, verb-phrase, and verbal-modifier grammars must be used. The reason for the construction of several smaller grammars instead of one large grammar concerns the large number of sentence types and the extremely low frequencies of occurrence within each type which one large grammar would have to generate. This has been more fully explained in the second chapter.

The grammar for complete utterances has been written as three separate grammars, a grammar for statements with verbs, a grammar for statements without verbs, and a grammar for interrogatives. Originally a fourth grammar was planned--one for compound sentences; however, this type of utterance comprised only 1.1% of the corpus, and the type frequencies were too low for statistical analysis. No grammar was written, but further details of the compound utterances will be given later in this chapter.

A total of six grammars, then, have been constructed for the corpus; the number of phrases involved of each of these and for the compound utterances has been summarized in Table 9.

Insert Table 9 about here

The noun-phrase grammar will be presented first and will be used to illustrate a phrase-structure grammar as well as to demonstrate the details of the statistical analysis including the assignment of parameters, the determination of the theoretical probabilities, the maximum-likelihood function, and the calculation of the chi-square values. This form of analysis was followed for all grammars, and will not again be reported in such detail.

Noun-Phrase Grammar

The rewrite rules of the noun-phrase grammar are shown in Table 10. The complete noun-phrase grammar includes some transformations, but these will be explained later.

Insert Table 10 about here

The symbols used in Table 10 (and throughout this paper) have the meanings commonly assigned to them by linguists:

$\rightarrow$: rewrite as
$\{\}$: choose at most one from within
( ): may delete contents

The meanings of the abbreviations may be found in Table 2.(Chapter II)

Table 11 shows the parameters which have been assigned to the choice points of the grammar. Throughout this paper variables which must sum to one have the same name and different subscripts. Thus in the noun-phrase grammar, $A_1+A_2+A_3+A_4 = 1$, $B1_1+B1_2 = 1$, and $B2_1+B2_2+B2_3 = 1$. Capital letters will be used for parameters because many of the tables are in computer output off of Model-33 teletypes which do not have the more traditional small Greek letters.

Insert Table 11 about here

The parameters incidated in Table 11 represent the following probabilities:

TABLE 9

Number of Phrases or Utterances to be Generated by each Grammar for each Section of the Corpus

Text	Noun Phrases	Verb Phrases	Verbal Modifiers	Statements with Verbs	Statements without Verbs	Interrogatives	Compound Statements
Ginn Pre-Primer	780	894	304	691	148	19	0
Scott-Foresman Pre-Primer	685	657	316	484	113	40	1
Pre-Primers Combined	1465	1551	620	1175	261	59	1
Ginn Primer	1687	1391	647	985	250	102	6
Scott-Foresman Primer	1516	1186	706	762	186	64	28
Primers Combined	3203	2577	1353	1747	436	166	34
Ginn Reader	3123	2020	1426	1568	256	83	18
Scott-Foresman Reader	2724	1837	1320	1150	196	69	35
Readers Combined	5847	3857	2746	2718	452	152	53
All Combined	10515	7985	4719	5640	1149	377	88

TABLE 10

Rewrite Rules of the Noun-Phrase Grammar

$NP \rightarrow P$

$NP \rightarrow G$

$NP \rightarrow (T) + (\left\{\begin{matrix}A\\A+A\end{matrix}\right\}) + N$

$NP \rightarrow A + A + A + N$

TABLE 11

Rewrite Rules and Parameters of the Noun-Phrase Grammar

Rewrite Rules	Parameters		
	Rule-Choice Probabilities	Within-Rule-Choice Probabilities	
$NP \rightarrow P$	A_1		
$NP \rightarrow G$	A_2		
$NP \rightarrow (T) + (\left\{\begin{matrix}A\\A+A\end{matrix}\right\}) + N$	A_3	$B1_1$ $B1_2$	$B2_1$ $B2_2$ $B2_3$
$NP \rightarrow A + A + A + N$	A_4		

A_1: Probability of choosing the first noun-phrase rule
A_2: Probability of choosing the second noun-phrase rule
A_3: Probability of choosing the third noun-phrase rule
A_4: Probability of choosing the fourth noun-phrase rule
$B1_1$: Probability of choosing "T"
$B1_2$: Probability of deleting "T"
$B2_1$: Probability of choosing "A"
$B2_2$: Probability of choosing "A+A"
$B2_3$: Probability of deleting either choice

Note that while nine parameters have been indicated for this model, only six of the parameters are free to vary; the remaining three will be determined because of the three sets of parameters which must sum to one.

The theoretical probabilities of each string derivable from the grammar can now be determined according to the generation rules; the usage of the generation rules is best illustrated by a phrase-marker. For example, consider the string, (T+A+N).

Phrase-Marker	Choice Probabilities
NP	A_3
↓	
T+A+N	$B1_1$, $B2_1$

The theoretical probability of any grammatical type is the product of the choice probabilities; in this case the theoretical probability is:

$$1)\quad A_3 \cdot B1_1 \cdot B2_1$$

Note that for this grammar and all other grammars, the generation ends with a non-terminal vocabulary of words describing parts of speech rather than a terminal vocabulary of words such as: "the", "girl", "pretty", etc.

In this way the theoretical probabilities of all strings derivable from the grammar can be determined. These are presented in Table 12.

Insert Table 12 about here

As Table 12 shows, nine types of noun phrases are derivable from the model and six free parameters are used in the theoretical probabilities. Thus the original model allows two degrees of freedom. The number of degrees of freedom for this grammar and for the following grammars is sometimes decreased because of low predicted frequencies; whenever the

TABLE 12

Types Derivable from the Noun-Phrase Grammar
and their Theoretical Probabilities

Type	Theoretical Probability
P	A_1
G	A_2
N	$A_3 \cdot B1_2 \cdot B2_3$
A+N	$A_3 \cdot B1_2 \cdot B2_1$
A+A+N	$A_3 \cdot B1_2 \cdot B2_2$
T+N	$A_3 \cdot B1_1 \cdot B2_3$
T+A+N	$A_3 \cdot B1_1 \cdot B2_1$
T+A+A+N	$A_3 \cdot B1_1 \cdot B2_2$
A+A+A+N	A_4

predicted frequency of a type was less than five, the observed and predicted frequencies of that type were combined with those of the following types until the total predicted frequency was greater than five. One degree of freedom was lost each time one cell was combined with another. This will be illustrated when the statistics for the noun-phrase grammar are presented.

The parameters were estimated according to the method of maximum-likelihood. This method is easily applicable as long as the grammar is unambiguous; that is, as long as each syntactical type can be generated in only one way. This can be seen to be the case for the noun-phrase grammar and for all the remaining grammars with the exception of one utterance type in the grammar for interrogatives. When more than one derivation for a given syntactic type is possible, the maximum-likelihood method is still workable, but the calculations are much more difficult. The theoretical probability for a type with more than one derivation consists of a sum of terms similar to the probability given on line 1, and this greatly increases the complexity of the likelihood function.

The likelihood function consists of a product of N terms where N is the number of different grammatical types derivable from the grammar. For the noun phrase grammar N is nine. Each term is the theoretical probability of one of the syntactical types raised to the power which is the number of occurrences of that type. For the noun phrases the likelihood function is:

$$2)\quad (A_1)^{f_P}\cdot(A_2)^{f_G}\cdot(A_3\cdot B1_2\cdot B2_3)^{f_N}\cdot(A_3\cdot B1_2\cdot B2_1)^{f_{A+N}}\cdot(A_3\cdot B1_2\cdot B2_2)^{f_{A+A+N}}\cdot$$
$$(A_3\cdot B1_1\cdot B2_3)^{f_{T+N}}\cdot(A_3\cdot B1_1\cdot B2_1)^{f_{T+A+N}}\cdot(A_3\cdot B1_1\cdot B2_2)^{f_{T+A+A+N}}\cdot$$
$$(A_4)^{f_{A+A+A+N}}$$

where "f" stands for observed frequency and the type is indicated as a subscript. Note that in the case of a grammar which generates an infinite number of types, the likelihood function is truncated in terms of frequencies. The likelihood function does not reflect any decision about the existence of a fixed finite number of syntactical types in the corpus; it is only a decision relative to frequencies in the corpus.

The maximum-likelihood estimates were then substituted into the theoretical probabilities to obtain numerical theoretical probabilities, and the products of these with the total number of phrases give the theoretical frequencies. Chi-square values were then computed to determine the goodness-of-fit of the predicted frequencies to the observed frequencies.

To complete the noun-phrase grammar some obligatory transformations were necessary. Such transformations are applied after all applicable generation rules have been used and are used to handle cases in which under certain conditions exceptions from the generative rules always occur. For the noun-phrase grammar the obligatory transformations are:

a) If "N" is "something", $A+N \rightarrow N+A$.

b) If "A" is "what" or "all", $T+A+N \rightarrow A+T+N$.

c) If "A_1" is "what" or "all", $T+A_1+A_2+N \rightarrow A_1+T+A_2+N$.

Transformation (a) is necessary to transform a phrase like "red something" (A+N) into "something red" (N+A); transformations (b) and (c) change phrases like "the all children" (T+A+N) and "a what big ball" (T+A+A+N) to "all the children" (A+T+N) and "what a big ball" (A+T+A+N).

To generate a string given by a transformation, the string to which the transformation is applied is derived according to the generative rules. Then, if the terminal vocabulary selected for the non-terminal string satisfies the assumptions of the transformation, the transformation is automatically applied. This means that for purposes of analysis, instances of strings which are generated by obligatory transformations are counted as occurrences of the corresponding strings before the transformation. Thus the observed frequency of the grammatical type (A+N) is the sum of the frequencies of type (A+N) and type (N+A) where "N" was chosen to be "something." Obligatory transformations do not effect the number of parameters or the theoretical probabilities.

Optional transformations are also possible, and these do effect the number of parameters and the theoretical probabilities. The possible need for optional transformations is apparent in grammars for complete sentences; for example, one might want to change "I am coming." to "I come." some of the time, but not always. This choice could be made available by an optional transformation. Optional transformations require a parameter for each option, and these parameters become terms in the products representing the theoretical probabilities. The parameter estimation and the remaining statistical analyses are the same whether or not optional transformations are used. Optional transformations were not necessary for the noun-phrase grammar or for any of the phrase-structure grammars. The categorial grammar for noun phrases, given in the fourth chapter, does use an optional transformation.

For the noun-phrase grammar the analysis described above was run on the individual sections of the corpus--the Ginn pre-primer, the Scott-Foresman pre-primer, the pre-primers combined, the Ginn primer, the Scott-Foresman primer, the primers combined, the Ginn (first) reader, the Scott-Foresman reader, and the readers combined--as well as on the entire corpus. This was true of the other grammars whenever the type frequencies were sufficiently large. Tables 13-16 summarize the results of the noun-phrase analysis. Table 13 shows the percent of each section of the corpus accounted for by the grammar (that is, the percent of utterances in the corpus whose syntactical types are derivable from the grammar); Table 14 gives the maximum-likelihood estimates; Table 15 provides a comparison of the total chi-squares for each section; and Table 16 shows for each section the observed and theoretical frequencies and corresponding chi-square contributions of each type. All computations for Tables 14-16 and other tables of a similar nature were carried out with five decimal digits; the resulting values were rounded off at the time of output to those shown in the tables.

Insert Tables 13-16 about here

The second page of Table 16, the page for the Scott-Foresman pre-primer, illustrates all of the notation used in this table and in the corresponding tables for the remaining grammars. The source designated "Expected Freq. Less Than 5.0" is the total from categories which have been combined because of low expected frequencies; it occurs whenever the expected frequency has accumulated to 5.0. For the Scott-Foresman pre-primer, the observed and expected values of this source are the sums of the corresponding values of types (A+A+N) and (T+A+A+N); the chi-square is obtained from the total values. Here two categories were combined into one, and so one degree of freedom was lost at this point. A second degree of freedom was lost because for the last type, (A+A+A+N), the expected frequency was again less

TABLE 13

Percent of each Section of the Corpus Accounted for by the Noun-Phrase Grammar

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
99.0	98.1	98.6	98.6	97.8	98.2	98.7	97.3	98.0	98.2

TABLE 14

Maximum-likelihood Estimates for each Section of the Corpus for the Noun-Phrase Grammar

Parameter	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
A_1	.2979	.6309	.4529	.4369	.5290	.4803	.3710	.3761	.3733	.4171
A_2	.3290	.1964	.2673	.1719	.1484	.1608	.1535	.1218	.1389	.1635
A_3	.3718	.1726	.2791	.3810	.3205	.3525	.4677	.4960	.4808	.4135
A_4	.0013	.0000	.0007	.0102	.0020	.0064	.0078	.0060	.0070	.0059
$B1_1$	.6272	.4741	.5831	.5820	.5453	.5663	.6142	.4631	.5421	.5522
$B1_2$	.3728	.5259	.4169	.4180	.4547	.4337	.3858	.5369	.4579	.4477
$B2_1$	.2265	.3276	.2556	.3502	.3958	.3697	.3338	.3939	.3625	.3543
$B2_2$	.0871	.0776	.0844	.1561	.1495	.1533	.1312	.0973	.1150	.1221
$B2_3$	.6864	.5948	.6600	.4937	.4547	.4770	.5350	.5087	.5225	.5237

TABLE 15

Comparison of Total Chi-Squares for Noun-Phrase Grammar

Text	No. of Phrases Accounted For	Total Chi-Square	Degrees of Freedom
Ginn Pre-Primer	772	.5	1
Scott-Foresman Pre-Primer	672	2.3	0
Pre-Primers Combined	1444	1.3	1
Ginn Primer	1664	52.2	2
Scott-Foresman Primer	1482	42.6	1
Primers Combined	3146	95.3	2
Ginn Reader	3081	81.5	2
Scott-Foresman Reader	2651	177.5	2
Readers Combined	5732	247.6	2
All Combined	10322	316.8	2

TABLE 16

Observed and Expected Frequencies, Chi-Square Contributions, and Total Chi-Squares for each Section of the Corpus for Noun-Phrase Grammar

GINN PRE-PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   230    230.0       .0  P
   254    254.0       .0  G
    76     73.4       .1  N
    23     24.2       .1  A+N
     8      9.3       .2  A+A+N
   121    123.6       .1  T+N
    42     40.8       .0  T+A+N
    17     15.7       .1  T+A+A+N
     1      1.0           A+A+A+N


     1      1.0           RESIDUAL

   772    772.0       .5  TOTAL

                    1     DEGREES OF FREEDOM
```

SCOTT-FORESMAN PRE-PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   424    424.0       .0  P
   132    132.0       .0  G
    33     36.3       .3  N
    24     20.0       .8  A+N
     4      4.7           A+A+N
    36     32.7       .3  T+N
    14     18.0       .9  T+A+N
     5      4.3           T+A+A+N

     9      9.0       .0  EXPECTED FREQ. LESS THAN 5.0

     0       .0           A+A+A+N


     0       .0           RESIDUAL

   672    672.0      2.3  TOTAL

                    0     DEGREES OF FREEDOM
```

TABLE 16 (continued)

PRE-PRIMERS COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  654     654.0      .0   P
  386     386.0      .0   G
  109     110.9      .0   N
   47      42.9      .4   A+N
   12      14.2      .3   A+A+N
  157     155.1      .0   T+N
   56      60.1      .3   T+A+N
   22      19.8      .2   T+A+A+N
    1       1.0           A+A+A+N


    1       1.0           RESIDUAL

 1444    1444.0     1.3   TOTAL

                    1     DEGREES OF FREEDOM
```

GINN PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  727     727.0      .0   P
  286     286.0      .0   G
   86     130.8    15.4   N
  123      92.8     9.8   A+N
   56      41.4     5.2   A+A+N
  227     182.2    11.0   T+N
   99     129.2     7.1   T+A+N
   43      57.6     3.7   T+A+A+N
   17      17.0      .0   A+A+A+N


    0        .0           RESIDUAL

 1664    1664.0    52.2   TOTAL

                    2     DEGREES OF FREEDOM
```

TABLE 16 (continued)

SCOTT-FORESMAN PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  784     784.0      .0  P
  220     220.0      .0  G
   63      98.2    12.6  N
  110      85.5     7.0  A+N
   43      32.3     3.6  A+A+N
  153     117.8    10.5  T+N
   78     102.5     5.9  T+A+N
   28      38.7     3.0  T+A+A+N
    3       3.0          A+A+A+N

    3       3.0          RESIDUAL

 1482    1482.0    42.6  TOTAL

                      1  DEGREES OF FREEDOM
```

PRIMERS COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

 1511    1511.0      .0  P
  506     506.0      .0  G
  149     229.4    28.2  N
  233     177.8    17.1  A+N
   99      73.7     8.7  A+A+N
  380     299.6    21.6  T+N
  177     232.2    13.1  T+A+N
   71      96.3     6.6  T+A+A+N
   20      20.0      .0  A+A+A+N

    0        .0          RESIDUAL

 3146    3146.0    95.3  TOTAL

                      2  DEGREES OF FREEDOM
```

TABLE 16 (continued)

GINN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  1143   1143.0      .0  P
   473    473.0      .0  G
   215    297.5    22.9  N
   238    185.6    14.8  A+N
   103     72.9    12.4  A+A+N
   556    473.5    14.4  T+N
   243    295.4     9.3  T+A+N
    86    116.1     7.8  T+A+A+N
    24     24.0      .0  A+A+A+N

     0       .0          RESIDUAL

  3081   3081.0    81.5  TOTAL

                      2  DEGREES OF FREEDOM
```

SCOTT-FORESMAN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   997    997.0      .0  P
   323    323.0      .0  G
   239    359.2    40.2  N
   370    278.1    30.4  A+N
    97     68.7    11.6  A+A+N
   430    309.8    46.6  T+N
   148    239.9    35.2  T+A+N
    31     59.3    13.5  T+A+A+N
    16     16.0      .0  A+A+A+N

     0      -.0          RESIDUAL

  2651   2651.0   177.5  TOTAL

                      2  DEGREES OF FREEDOM
```

TABLE 16 (continued)

READERS COMBINED

```
OBSERV.   EXPECT.   CHI**2  SOURCE

  2140    2140.0       .0   P
   796     796.0       .0   G
   454     659.4     64.0   N
   608     457.5     49.5   A+N
   200     145.2     20.7   A+A+N
   986     780.6     54.0   T+N
   391     541.5     41.9   T+A+N
   117     171.8     17.5   T+A+A+N
    40      40.0       .0   A+A+A+N

     0        .0            RESIDUAL

  5732    5732.0    247.6   TOTAL

                        2   DEGREES OF FREEDOM
```

ALL COMBINED

```
OBSERV.   EXPECT.   CHI**2  SOURCE

  4305    4305.0       .0   P
  1688    1688.0       .0   G
   712    1000.7     83.3   N
   888     677.0     65.8   A+N
   311     233.3     25.9   A+A+N
  1523    1234.3     67.5   T+N
   624     835.0     53.3   T+A+N
   210     287.7     21.0   T+A+A+N
    61      61.0       .0   A+A+A+N

     0       -.1            RESIDUAL

 10322   10322      316.8   TOTAL

                        2   DEGREES OF FREEDOM
```

than five. The line labeled "Residual" contains types such as (A+A+A+N) whose individual predicted frequencies were less than 5 and whose total predicted frequency was less than 5; that is, the residual contains all types whose predicted frequencies were less than 5 and which fell below the last "Expected Freq. Less Than 5.0" line. The residual also contains round-off errors (causing some negative values) and the values (observed frequency, predicted frequency, and chi-square contribution) for unlisted types. Unlisted types are those generated by the grammar but not included separately in the source column. The phrase-structure grammars generate a finite number of types and these are all listed so there will never be unlisted types; the verb-phrase categorial grammar, however, generates an infinite number of types and the values of those with non-zero probabilities will be included in the residual. When the expected frequency of the residual is greater than 5 (possible because of unlisted types), the chi-square is evaluated and one degree of freedom is added; otherwise it is not. Due to the two degrees of freedom lost through collapsing, the noun-phrase grammar for the Scott-Foresman pre-primer has zero degrees of freedom. The chi-square for this part of the corpus must be studied for descriptive purposes only and must not be used to determine significance levels.

As Table 13 indicates, the noun-phrase grammar accounts for a very high percent (98.2%) of the noun phrases in the entire corpus, and for a nearly equivalent percent of each section of the corpus. It does not generate any types which do not appear in the corpus; in fact, all derivable types occur at least 60 times in the corpus as a whole. Thus according to the criteria of generating all types appearing in the corpus, and only those, this grammar is very good.

The chi-square tables (Tables 15 and 16) indicate the "goodness" of the grammar with regard to type frequency. In discussions of the chi-square values the term "comparative chi-square value" will be used to indicate that any differences in degrees of freedom have been considered and the effects incorporated into the comparisons. When differences in degrees of freedom made comparisons difficult, an F-test of significance was used. For the noun-phrase grammar the comparative chi-square values increase significantly form the pre-primers to the primers and from the primers to the readers, indicating that with regard to frequency the grammar is much more representative of the pre-primers than the primers and readers. For the pre-primers and primers the comparative chi-squares for the Ginn and Scott-Foresman books are roughly equivalent, but for the readers the Scott-Foresman chi-square is considerably greater. With respect to type frequency, the grammar is a much better representation of the Ginn reader than the Scott-Foresman reader.

With the exception of the pre-primers the comparative chi-square values are higher for the combined volumes than for either volume separately, and the comparative chi-square for the total corpus is the largest of all. This trend indicates the difference in noun-phrase type-frequency patterns for the two reading series and for the different sections within each series. The difference is apparent in the observed frequencies, and is most obvious in the readers. The Scott-Foresman reader, for example, has more phrases of type (N) than of any other type containing "N", while in the Ginn reader phrases of types (A+N), (T+N), and (T+A+N) all have greater frequencies than phrases of type (N).

Table 16 gives further details regarding the chi-square values. The first, second, and last noun phrase types, (P), (G), and (A+A+A+N), contributed nothing to the chi-square value because the theoretical probabilities of each of these types consisted of only one parameter. For the pre-primers and the pre-primers combined the comparative chi-square values are consistently low. For the remaining sections consistently high contributers to the total chi-square are the (N), (A+N), and (T+N) types, with predictions for type (N) being consistently high and predictions for types (A+N) and (T+N) being consistently low. For the readers individually and combined the predictions for the (T+A+N) types are high yielding additionally large chi-square contributions. The table also shows that the great difference in total chi-square between the Ginn and Scott-Foresman readers is caused by higher contributions for all types in the Scott-Foresman book rather than one extremely large contribution from one or a few types.

Figure 1 shows the fit of the noun-phrase grammar to the entire corpus. The observed frequencies were arranged in rank order and plotted accordingly; the predicted frequencies were plotted at the rank of their corresponding observed value.

Insert Figure 1 about here

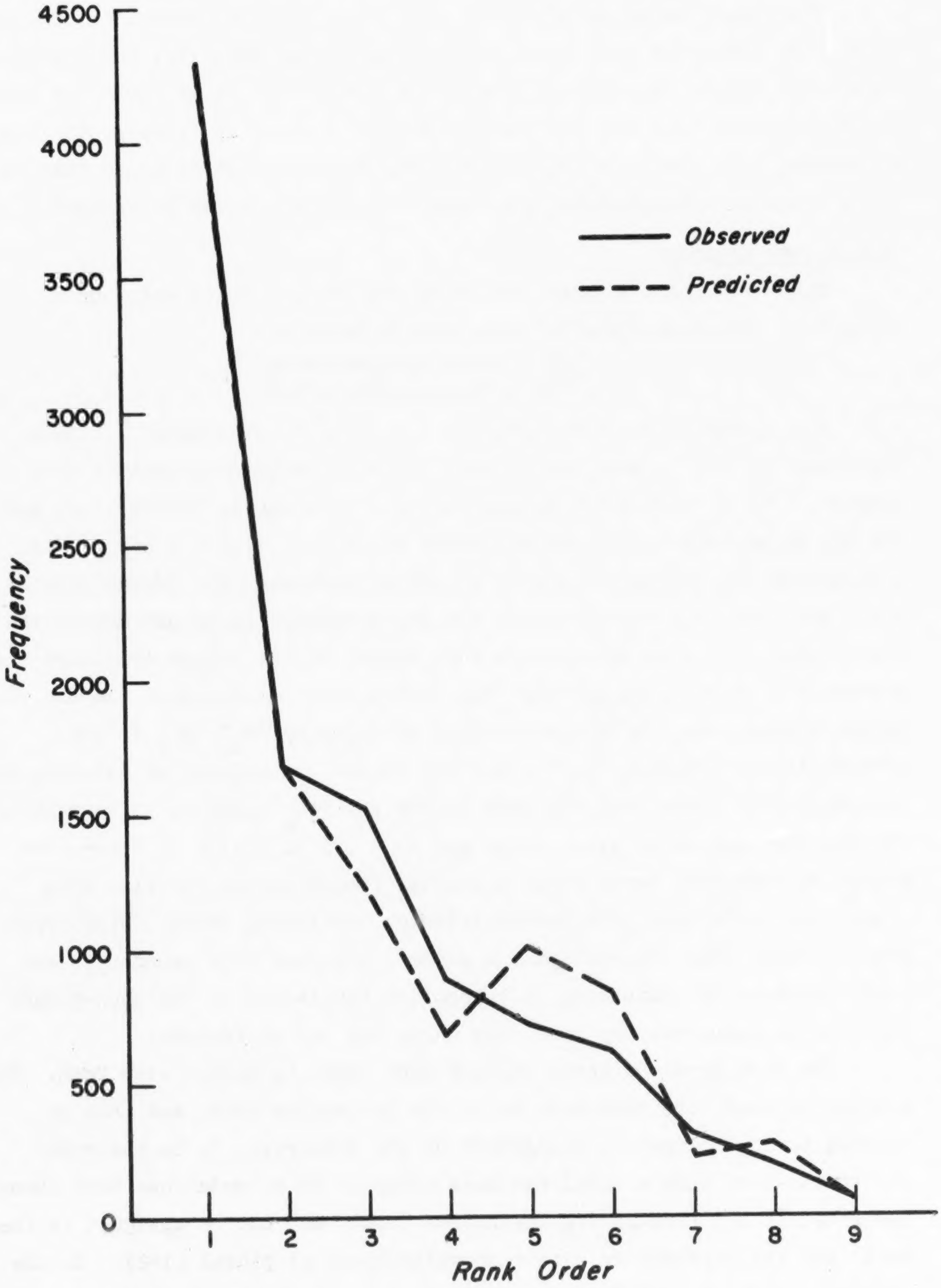

Fig. 1. Comparison of observed and predicted frequencies for noun phrases (entire corpus).

The figure shows an extremely good fit. With the exception of type (A+N), the predicted rank order is the same as the observed, and the two curves are nearly identical. However in view of the large number of parameters which have been used and the small number of degrees of freedom, it is not surprising that some sort of fit has been obtained. It is hoped that in a later stage of investigation the number of parameters can be reduced.

Verb-Phrase Grammar

The verb-phrase grammar including the rewrite rules and four obligatory transformations is presented in Table 17.

Insert Table 17 about here

The parameter notation used for the noun-phrase grammar has been continued for the verb-phrase grammar and will be used throughout this chapter. The A_i parameters always denote a rule-choice probability, and the Bj_i parameters denote probabilities of choices within a given rule. In a column of Bj_i parameters the first member indicates the probability of the first (the top) choice within the parentheses, the second member the second choice, and so on, and the last member of the column indicates the probability of choosing nothing from that set of parentheses. In the verb-phrase grammar, Bl_1 is the probability of choosing "M_3", $B2_1$ is the probability of choosing "M_3+-", and Bl_3 is the probability of deleting both possibilities. Note that the same parameters were assigned to corresponding choices for each verb type. There was no a priori reason to think that modals or negatives would occur a greater proportion of the time with transitive verbs than with intransitive or copulative verbs. Nine types are derivable from the verb-phrase grammar and four free parameters are used; whenever no collapsing of categories (explained in the noun-phrase section) is required, the model has three degrees of freedom.

The verb phrase grammar employs subscripts to denote verb form. When a modal is used, the verb must be in the infinitive form, and this is denoted by the obligatory assignment of the subscript, 3, to the modal and to the verb once a modal has been chosen. If no modal has been chosen, the subscript, 3 (indicating infinitive form), may not be assigned to the verb, but the verb may be either singular (i=1) or plural (i=2). In the utterance grammars subscripts will be assigned to the subjective noun

TABLE 17

The Verb-Phrase Grammar

Rewrite Rules	Parameters	
	Rule-Choice Probabilities	Within-Rule-Choice Probabilities
$VP \rightarrow \left\{\begin{matrix} M_3 \\ M_3+- \end{matrix}\right\} +IV_i$	A_1	Bl_1 Bl_2 Bl_3
$VP \rightarrow \left\{\begin{matrix} M_3 \\ M_3+- \end{matrix}\right\} +TV_i$	A_2	Bl_1 Bl_2 Bl_3
$VP \rightarrow \left\{\begin{matrix} M_3 \\ M_3+- \end{matrix}\right\} +CV_i$	A_3	Bl_1 Bl_2 Bl_3

$i = 1 \Rightarrow$ singular verb form
$i = 2 \Rightarrow$ plural verb form
$i = 3 \Rightarrow$ infinitive verb form $\Leftrightarrow M_3$ occurs

Obligatory transformations:

1. If M_3 is a form of "to be", $\left\{\begin{matrix} IV_3 \\ TV_3 \\ CV_3 \end{matrix}\right\} \rightarrow \left\{\begin{matrix} IV_3+ing \\ TV_3+ing \\ CV_3+ing \end{matrix}\right\}$

2a. If IV_3 is a form of "to be" or "to do" and M_3 is a form of "to be" or "to do", $M_3+-+IV_3 \rightarrow IV_i+-$, $i \neq 3$.[3]

2b. If IV_i is "will", "can", "may", "must", "shall", or "could", $M_3+-+IV_3 \rightarrow IV_i+-$, $i \neq 3$.

3. If TV_3 is a form of "to be" and M_3 is a form of "to be" or "to do", $M_3+-+TV_3 \rightarrow TV_i+-$, $i \neq 3$.[3]

4. If CV_3 is a form of "to be" and M_3 is a form of "to be" or "to do",

phrases and to the verbs so that subjects and predicates will be forced to agree in number and person. However no parameters will be assigned to the choice of subscripts; that is, types with singular subjects and predicates will not be distinguished from the corresponding types with plural subjects and predicates. In a complete grammar this distinction might be made, but the problem of many types with low frequencies precluded doing so at this stage.

Because forms of the verb "to be" are available choices for "M_3", transformation 1 is required to change phrases like "is go" and "are come" to "is going" and "are coming". Transformations 2 - 4 were necessary to change phrases like "am not being" and "do not be" into "am not" and "do not". While English usage does permit the untransformed forms (as in "She is not being very nice." and "Do not be that way."), the untransformed forms were not used in this corpus. Transformation 2a, involving intransitive verbs, changes phrases like "does not do" into "does not", so utterances like "She does not." are derivable from the utterance grammar; however, transformation 3, involving transitive verbs, does not allow this transformation, and so utterances like "He does not do his homework." are also derivable from the utterance grammar.

No work with verb tense has been done in this analysis. For the most part in this corpus past and future tenses are formed through the use of the auxiliaries "did" and "will". Some use of "ed" endings is made, but a refinement of the analysis to include tense characteristics at this point would only serve to confuse the presentation and statistical analysis of the more important structural characteristics.

Tables 18 through 21 present the statistical analysis of the verb-phrase grammar. On the tables subscripts are shown in parentheses. It should be noted that instances of modal plus verb combinations in which the modal and verb were necessarily separated (as in interrogatives such as "May she come out with us?") were included in the frequency counts of the respective modal plus verb types. Some contractions such as "can't" and "don't" were used; these were considered to be transformations of the terminal vocabulary and as such were not distinguished from the corresponding uncontracted forms. Similarly, in the grammars for complete utterances, the subject-verb contractions such as "I'll" and the verb-object contractions such as "let's" were treated as the uncontracted forms.

Insert Tables 18-21 about here

TABLE 18

Percent of each Section of the Corpus Accounted for by the Verb-Phrase Grammar

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
100	100	100	100	99.7	99.8	99.6	99.7	99.7	99.8

TABLE 19

Maximum-likelihood Estimates for each Section of the Corpus for the Verb-Phrase Grammar

Parameter	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
A_1	.5671	.5662	.5667	.4968	.4560	.4780	.5383	.4820	.5114	.5114
A_2	.4228	.4277	.4249	.4508	.5102	.4780	.4289	.4842	.4553	.4567
A_3	.0101	.0061	.0084	.0525	.0338	.0439	.0328	.0338	.0333	.0319
$B1_1$	.0805	.1537	.1115	.1503	.1286	.1403	.1605	.1124	.1376	.1334
$B1_2$	.0190	.0654	.0387	.0604	.0956	.0766	.0711	.0617	.0666	.0644
$B1_3$	.9004	.7808	.8498	.7894	.7758	.7831	.7684	.8259	.7958	.8022

TABLE 20

Comparison of Total Chi-Squares for the Verb-Phrase Grammar

Text	No. of Phrases Accounted For	Total Chi-Square	Degrees of Freedom
Ginn Pre-Primer	894	4.9	2
Scott-Foresman Pre-Primer	657	41.4	1
Pre-Primers Combined	1551	33.5	2
Ginn Primer	1391	34.9	3
Scott-Foresman Primer	1182	36.9	3
Primers Combined	2573	69.1	4
Ginn Reader	2012	72.9	3
Scott-Foresman Reader	1832	12.9	3
Readers Combined	3844	57.3	4
All Combined	7968	159.1	4

TABLE 21

Observed and Expected Frequencies, Chi-Square Contributions, and Total Chi-Squares for each Section of the Corpus for the Verb-Phrase Grammar

GINN PRE-PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  462     456.5      .1   IV
   34      40.8     1.1   M+IV
   11       9.6      .2   M+-+IV
  336     340.4      .1   TV
   38      30.4     1.9   M+TV
    4       7.2     1.4   M+-+TV
    7       8.1      .2   CV
    0        .7           M+CV
    2        .2           M+-+CV


    2        .9           RESIDUAL

  894     894.0     4.9   TOTAL

                    2     DEGREES OF FREEDOM
```

SCOTT-FORESMAN PRE-PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  325     290.5     4.1   IV
   30      57.2    12.9   M+IV
   17      24.3     2.2   M+-+IV
  187     219.4     4.8   TV
   68      43.2    14.2   M+TV
   26      18.4     3.1   M+-+TV
    1       3.1           CV
    3        .6           M+CV
    0        .3           M+-+CV


    4       4.0           RESIDUAL

  657     657.0    41.4   TOTAL

                    1     DEGREES OF FREEDOM
```

TABLE 21 (continued)

PRE-PRIMERS COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   787    747.0     2.1   IV
    64     98.0    11.8   M+IV
    28     34.0     1.1   M+-+IV
   523    560.0     2.4   TV
   106     73.5    14.4   M+TV
    30     25.5      .8   M+-+TV
     8     11.0      .8   CV
     3      1.5           M+CV
     2       .5           M+-+CV


     5      1.9           RESIDUAL

  1551   1551.0    33.5   TOTAL

                      2   DEGREES OF FREEDOM
```

GINN PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   579    545.4     2.1   IV
    75    103.8     8.0   M+IV
    37     41.7      .5   M+-+IV
   455    494.9     3.2   TV
   131     94.2    14.4   M+TV
    41     37.9      .3   M+-+TV
    64     57.6      .7   CV
     3     11.0     5.8   M+CV
     6      4.4           M+-+CV


     6      4.4           RESIDUAL

  1391   1391.0    34.9   TOTAL

                      3   DEGREES OF FREEDOM
```

TABLE 21 (continued)

SCOTT-FORESMAN PRIMER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  459     418.2     4.0   IV
   53      69.3     3.8   M+IV
   27      51.5    11.7   M+-+IV
  428     467.8     3.4   TV
   97      77.5     4.9   M+TV
   78      57.6     7.2   M+-+TV
   30      31.0      .0   CV
    2       5.1     1.9   M+CV
    8       3.8           M+-+CV


    8       3.8           RESIDUAL

 1182    1182.0    36.9   TOTAL

                    3     DEGREES OF FREEDOM
```

PRIMERS COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  1038    963.3     5.8   IV
   128    172.6    11.5   M+IV
    64     94.2     9.7   M+-+IV
   883    963.3     6.7   TV
   228    172.6    17.8   M+TV
   119     94.2     6.5   M+-+TV
    94     88.5      .3   CV
     5     15.9     7.4   M+CV
    14      8.7     3.3   M+-+CV


     0      -.0           RESIDUAL

  2573   2573.0    69.1   TOTAL

                    4     DEGREES OF FREEDOM
```

TABLE 21 (continued)

GINN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  901     832.2     5.7  IV
  121     173.9    16.1  M+IV
   61      77.0     3.3  M+-+IV
  585     663.1     9.2  TV
  199     138.5    26.4  M+TV
   79      61.3     5.1  M+-+TV
   60      50.7     1.7  CV
    3      10.6     5.4  M+CV
    3       4.7          M+-+CV


    3       4.7          RESIDUAL

 2012    2012.0    72.9  TOTAL

                    3    DEGREES OF FREEDOM
```

SCOTT-FORESMAN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  755     729.2      .9  IV
   85      99.3     2.1  M+IV
   43      54.5     2.4  M+-+IV
  716     732.5      .4  TV
  109      99.7      .9  M+TV
   62      54.7     1.0  M+-+TV
   42      51.2     1.7  CV
   12       7.0     3.6  M+CV
    8       3.8          M+-+CV


    8       3.8          RESIDUAL

 1832    1832.0    12.9  TOTAL

                    3    DEGREES OF FREEDOM
```

TABLE 21 (continued)

READERS COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  1656   1564.5     5.4   IV
   206    270.6    15.4   M+IV
   104    130.9     5.5   M+-+IV
  1301   1392.6     6.0   TV
   308    240.8    18.7   M+TV
   141    116.5     5.1   M+-+TV
   102    101.9      .0   CV
    15     17.6      .4   M+CV
    11      8.5      .7   M+-+CV


     0      -.0           RESIDUAL

  3844   3844.0    57.3   TOTAL

                   4      DEGREES OF FREEDOM
```

ALL COMBINED

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  3481   3269.0    13.7   IV
   398    543.6    39.0   M+IV
   196    262.4    16.8   M+-+IV
  2707   2919.3    15.4   TV
   642    485.5    50.5   M+TV
   290    234.3    13.2   M+-+TV
   204    203.8      .0   CV
    23     33.9     3.5   M+CV
    27     16.4     6.9   M+-+CV

     0      -.1           RESIDUAL

  7968   7968.0   159.1   TOTAL

                   4      DEGREES OF FREEDOM
```

Table 18 shows that like the noun-phrase grammar, the verb-phrase grammar accounts for a very high percent of the verb phrases in the corpus. The only cases not included were those in which the modal and verb were separated by an adverb or adjective as in "He was slowly going to Tom." All types derivable from the grammar appear in the corpus.

Unlike the chi-squares for the noun-phrase grammar, the comparative chi-squares for the verb-phrase grammar show no significant increase from the pre-primers to the readers (Table 20); in fact the comparative chi-square for the readers combined is less, though not significantly less, than that for the primers combined. In addition the Scott-Foresman pre-primer has a relatively high comparative chi-square and the Scott-Foresman reader a relatively low comparative chi-square. Table 21 indicates the reason for this. In the assignment of parameters, the assumption was made that the proportion of modal plus verb and modal plus negative plus verb types was equivalent for all three kinds of verbs, and this assumption was more nearly fulfilled by the observed frequencies of the Scott-Foresman reader than by those of the Scott-Foresman pre-primer. In fact, as Table 21 indicates, most of the relatively high contributions to the chi-square values were the result of this assumption. In all but one instance (the Ginn pre-primer) the observed proportions of modal plus verb types and modal plus negative plus verb types are greater for transitive than for intransitive verbs.

In general the verb-phrase grammar provides a better fit than the noun-phrase grammar; with the exception of the pre-primers the total chi-squares are lower and the degrees of freedom are greater. However, these differences are significant at the .05 level only for the Scott-Foresman reader and the readers combined. In both grammars the power of the chi-square tests is very large because of the extremely large number of observations. The chance of being right in rejecting the null hypothesis is very high.

Figure 2 corresponds to Figure 1 for noun phrases and, like Figure 1, indicates an extremely good fit; again, however, the number of degrees of freedom is small, and some sort of fit would be expected. It should be noted that Figures 1 and 2 represent the fit for the entire corpus which had equivalent or larger comparative chi-squares than the individual sections. Thus similar figures for individual sections of the corpus would show fits which were as good or better than those indicated by Figures 1 and 2.

Insert Figure 2 about here

Grammar for Verbal Modifiers

The grammar for verbal modifiers is presented in Table 22. Twenty-nine syntactic types are derivable from the grammar and twenty free parameters are used; when no collapsing due to low predicted frequencies is needed, the model has eight degrees of freedom. No transformations were required.

Insert Table 22 about here

Table 23 shows that an extremely high percent of the verbal modifiers in each section of the corpus is derivable from the grammar, and the observed frequencies (Table 24) show that all derivable types are found at least once in the corpus.

Insert Tables 23 and 24 about here

Many types in the individual sections of the corpus had zero or very low frequencies, and so the chi-square values for these sections were not meaningful. When the theoretical probability of a type should be zero, any one of the parameters in the product can be zero and the remaining parameters can be given the values which give the best fit to the observed frequencies of other types. In the individual sections there were enough types of zero frequency to enable the grammar to give a perfect or nearly perfect fit. The problem is further indicated by the fact that for individual sections so much collapsing due to low predicted frequencies would have been necessary that all individual sections of the corpus with the exception of the Scott-Foresman reader and the readers combined would have had negative degrees of freedom. The statistical analysis was completed only for the entire corpus and is presented in Tables 25 and 26.

Insert Tables 25 and 26 about here

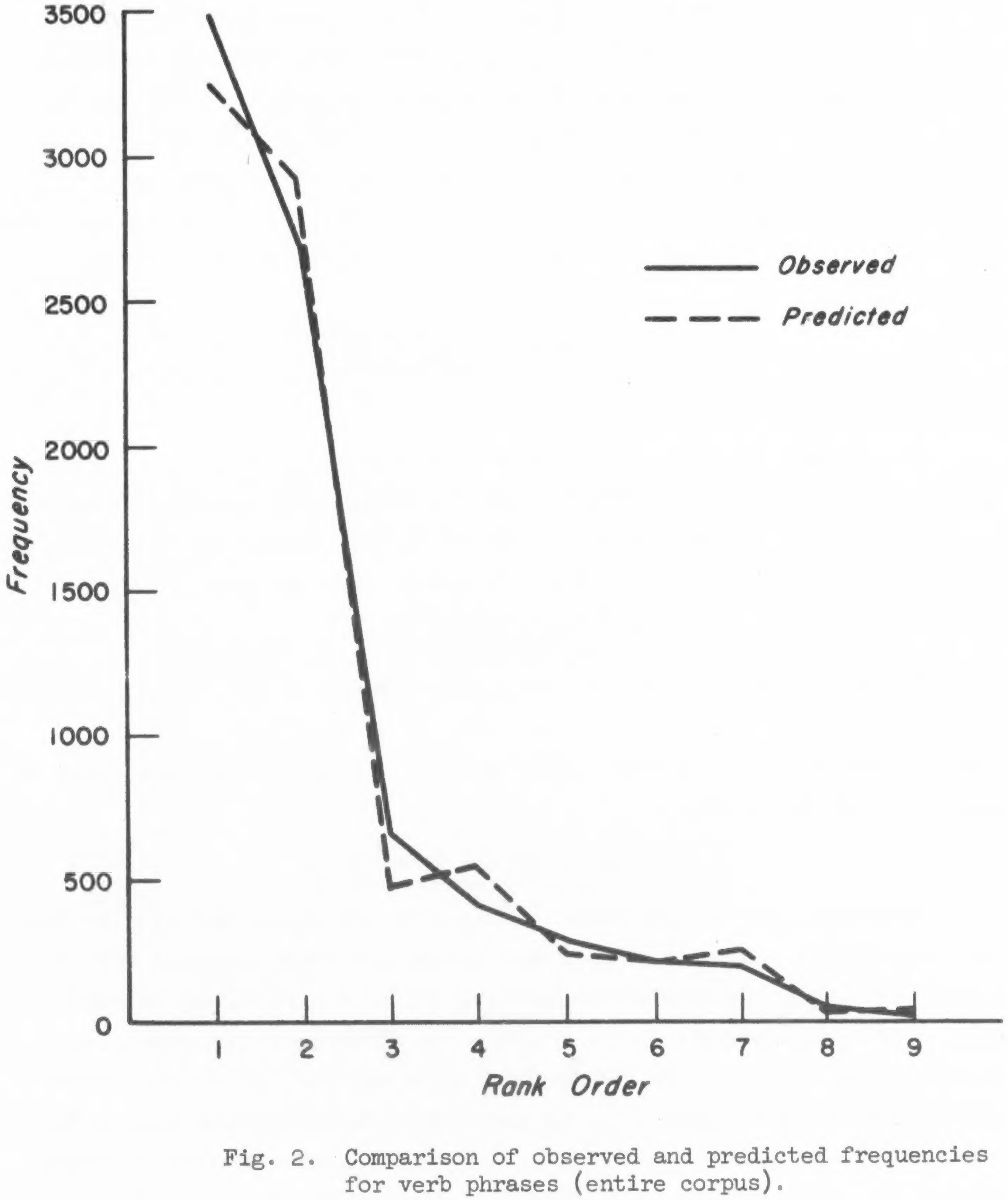

Fig. 2. Comparison of observed and predicted frequencies for verb phrases (entire corpus).

TABLE 22

The Grammar for Verbal Modifiers

Rewrite Rules	Parameters	
	Rule-Choice Probabilities	Within-Rule-Choice Probabilities
$VM \rightarrow (Adv) + J + NP + \left(\left\{\begin{matrix} NP \\ J+NP \\ Adv \\ C+NP \end{matrix}\right\}\right)$	A_1	$B1_1$ $B1_2$ $B2_1$ $B2_2$ $B2_3$ $B2_4$ $B2_5$
$VM \rightarrow Adv + \left(\left\{\begin{matrix} Adv \\ Adv+Adv \\ Adv+J+NP \\ C+Adv \\ L \end{matrix}\right\}\right)$	A_2	$B3_1$ $B3_2$ $B3_3$ $B3_4$ $B3_5$ $B3_6$
$VM \rightarrow L + \left(\left\{\begin{matrix} Adv \\ J+NP \end{matrix}\right\}\right)$	A_3	$B4_1$ $B4_2$ $B4_3$
$VM \rightarrow S + (J+NP)$	A_4	$B5_1$ $B5_2$
$VM \rightarrow I + (I)$	A_5	$B6_1$ $B6_2$
$VM \rightarrow J + L$	A_6	
$VM \rightarrow NP + \left(\left\{\begin{matrix} NP \\ J+NP \\ Adv \\ C+NP \end{matrix}\right\}\right)$	A_7	$B2_1$ $B2_2$ $B2_3$ $B2_4$ $B2_5$

2

00058

TABLE 23

Percent of each Section of the Corpus Accounted for by the Grammar for Verbal Modifiers

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
100	98.4	99.2	99.2	98.9	99.0	98.8	97.1	98.0	98.5

TABLE 24

Observed Frequencies of Verbal-Modifier Types in each Section of the Corpus

Type	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
J+NP	87	109	196	222	219	441	500	423	923	1560
J+NP+NP	0	0	0	0	0	0	2	6	8	8
J+NP+J+NP	0	0	0	10	10	20	60	36	96	116
J+NP+ADV	0	1	1	14	6	20	26	19	45	66
J+NP+C+NP	2	4	6	2	8	10	13	4	17	33
ADV	61	76	137	208	225	433	460	381	841	1411
ADV+ADV	1	2	3	18	12	30	57	67	124	157
ADV+ADV+ADV	0	0	0	0	0	0	4	5	9	9
ADV+ADV+J+NP	0	0	0	3	0	3	7	3	10	13
ADV+C+ADV	7	2	9	6	1	7	16	22	38	54
ADV+L	0	0	0	1	4	5	1	7	8	13
L	139	67	206	78	77	155	80	44	124	485
L+J+NP	0	3	3	6	3	9	1	5	6	18
S	0	0	0	0	27	27	9	20	29	56
S+J+NP	0	0	0	4	3	7	3	0	3	10
I	2	33	35	25	46	71	25	47	72	178
I+I	0	7	7	3	18	21	4	17	21	49
J+L	5	6	11	11	20	31	3	17	20	62
NP	0	0	0	0	2	2	17	50	67	69
NP+ADV	0	0	0	0	0	0	0	7	7	7
NP+J+NP	0	0	0	0	1	1	0	7	7	8
NP+C+NP	0	0	0	0	0	0	0	2	2	2
NP+NP	0	0	0	0	0	0	0	1	1	1
ADV+J+NP	0	1	1	26	13	39	105	78	183	223
ADV+J+NP+NP	0	0	0	0	0	0	0	1	1	1
ADV+J+NP+J+NP	0	0	0	0	0	0	5	6	11	11
ADV+J+NP+ADV	0	0	0	0	1	1	5	3	8	9
ADV+J+NP+C+NP	0	0	0	0	1	1	5	3	8	9
L+ADV	0	0	0	5	1	6	1	1	2	8

TABLE 25

Maximum-likelihood Estimates for the Entire Corpus
for the Grammar for Verbal Modifiers

Parameter	Value
A[1]	.4382
A[2]	.3566
A[3]	.1100
A[4]	.0142
A[5]	.0489
A[6]	.0133
A[7]	.0187
B1[1]	.1243
B1[2]	.8757
B2[1]	.0047
B2[2]	.0636
B2[3]	.0386
B2[4]	.0207
B2[5]	.8724
B3[1]	.0947
B3[2]	.0054
B3[3]	.0078
B3[4]	.0326
B3[5]	.0078
B3[6]	.8515
B4[1]	.0157
B4[2]	.0352
B4[3]	.9491
B5[1]	.1515
B5[2]	.8485
B6[1]	.2159
B6[2]	.7841

TABLE 26

Observed and Expected Frequencies, Chi-square Contributions, and Total Chi-square for the Entire Corpus for the Grammar for Verbal Modifiers

```
OBSERV.   EXPECT.   CHI**2   SOURCE

  1560    1555.4       .0    J+NP
     8       8.4       .0    J+NP+NP
   116     113.4       .1    J+NP+J+NP
    66      68.9       .1    J+NP+ADV
    33      37.0       .4    J+NP+C+NP
  1411    1411.0       .0    ADV
   157     157.0       .0    ADV+ADV
     9       9.0       .0    ADV+ADV+ADV
    13      13.0       .0    ADV+ADV+J+NP
    54      54.0       .0    ADV+C+ADV
    13      13.0       .0    ADV+L
   485     485.0       .0    L
    18      18.0       .0    L+J+NP
    56      56.0       .0    S
    10      10.0       .0    S+J+NP
   178     178.0       .0    I
    49      49.0       .0    I+I
    62      62.0       .0    J+L
    69      75.9       .6    NP
     7       3.4             NP+ADV
     8       5.5      1.1    NP+J+NP
     2       1.8             NP+C+NP

     9       5.2      2.9    EXPECTED FREQ. LESS THAN 5.0

     1        .4             NP+NP
   223     220.7       .0    ADV+J+NP
     1       1.2             ADV+J+NP+NP
    11      16.1      1.6    ADV+J+NP+J+NP
     9       9.8       .1    ADV+J+NP+ADV
     9       5.2      2.7    ADV+J+NP+C+NP
     8       8.0       .0    L+ADV

     2       1.6             RESIDUAL

  4646    4646.0      9.6    TOTAL

                        5    DEGREES OF FREEDOM
```

The total chi-square shown in Table 26 is extremely low and indicates the best fit of the three grammars presented so far. Figure 3 gives a further indication of the quality of this fit; the observed and predicted lines are nearly identical showing that the fit is close to perfect.

Insert Figure 3 about here

Grammar for Statements Without Verbs

The grammar for statements without verbs was written for such utterances as: "Oh, my.", "Hello, Dick!", and "What a pretty dress!" It is shown in Table 27.

Insert Table 27 about here

Twenty-two syntactic types are derivable from the grammar and 17 parameters are used; four degrees of freedom are available whenever no collapsing due to low predicted frequencies is necessary. The same parameter, Bl_1, was assigned to the choice of the vocative whether it occurred after a verbal modifier, an adjective, or a rejoinder; there was no a priori reason to think that the proportion of utterances such as "Over here, Sally." to "Over here." would be different than the proportion of utterances such as "Yes, Sally." to "Yes." Similarly, the same parameters, $B3_1$ and $B3_2$, were assigned to the first and second repetition of a sound as to the first and second repetition of a number or the uttering of a second and third number in a series.

The observed frequencies of the syntactic types for each section of the corpus are shown in Table 28, and the percent of utterances in each section of the corpus which were accounted for by the grammar is shown in Table 29. Again a very high percent of the statements without verbs can be generated by the grammar, and all derivable expressions occur in the corpus.

Insert Tables 28 and 29 about here

The problem of many zero or low frequency types discussed in connection with the verbal-modifier grammar reoccurred for this grammar. Only the corpus as a whole could meaningfully be analyzed by maximum-likelihood estimates and chi-squares. This analysis is given in Tables 30 and 31.

Insert Tables 30 and 31 about here

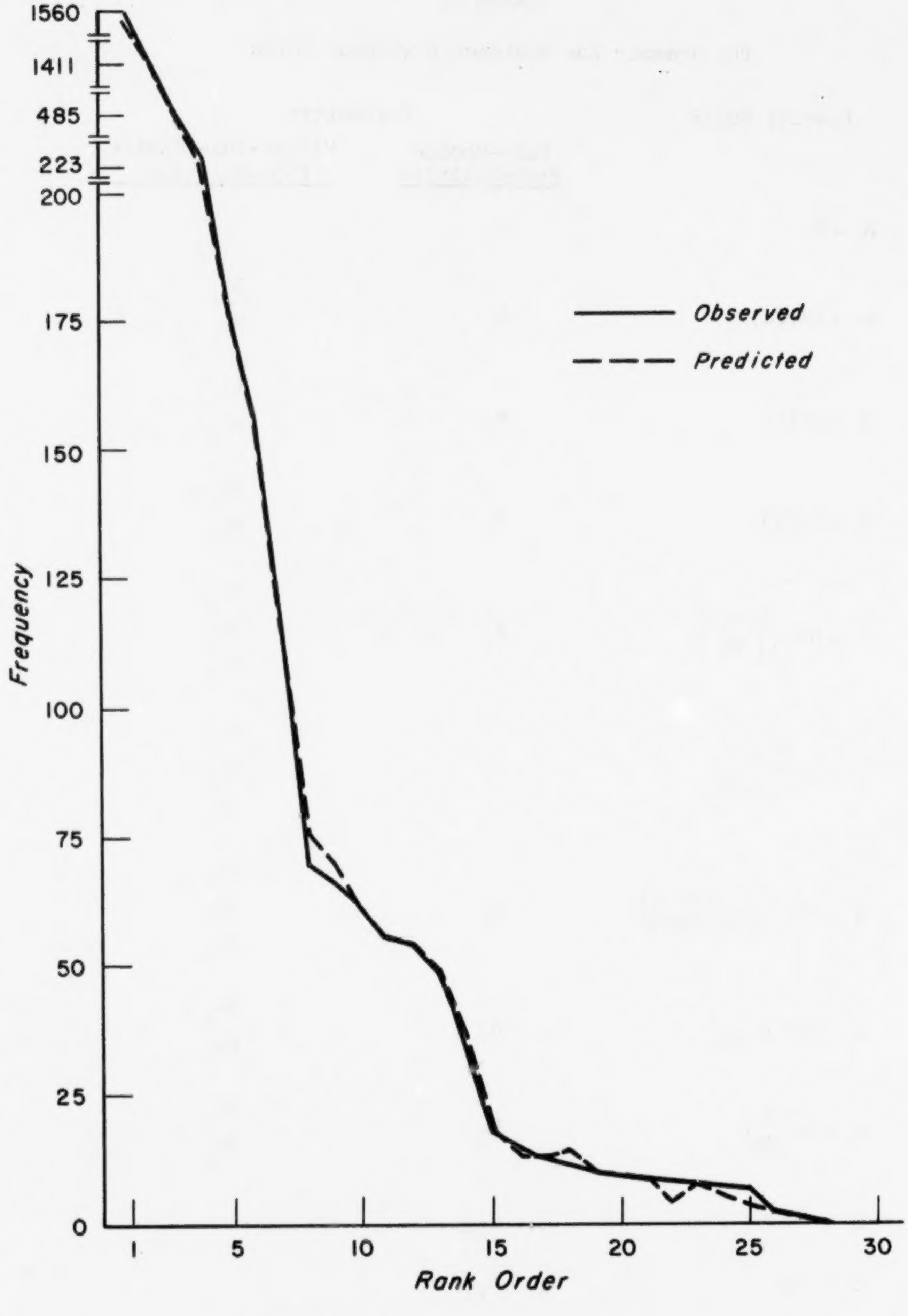

Fig. 3. Comparison of observed and predicted frequencies for verbal modifiers (entire corpus).

TABLE 27

The Grammar for Statements without Verbs

Rewrite Rules	Parameters	
	Rule-Choice Probabilities	Within-Rule-Choice Probabilities
$S \rightarrow K$	A_1	
$S \rightarrow VM+(K)$	A_2	$B1_1$ $B1_1$
$S \rightarrow A+(K)$	A_3	$B1_1$ $B1_2$
$S \rightarrow R+(K)$	A_4	$B1_1$ $B1_2$
$S \rightarrow NP+\left(\begin{Bmatrix} C+NP \\ VM \end{Bmatrix}\right)$	A_5	$B2_1$ $B2_2$ $B2_3$
$S \rightarrow Z+\left(\begin{Bmatrix} Z \\ Z+Z \end{Bmatrix}\right)$	A_6	$B3_1$ $B3_2$ $B3_3$
$S \rightarrow NBR+\left(\begin{Bmatrix} NBR \\ NBR+NBR \end{Bmatrix}\right)$	A_7	$B3_1$ $B3_2$ $B3_3$
$S \rightarrow VM+\begin{Bmatrix} A \\ K+VM \end{Bmatrix}$	A_8	$B4_1$ $B4_2$
$S \rightarrow R+\begin{Bmatrix} R \\ VM \end{Bmatrix}$	A_9	$B5_1$ $B5_2$
$S \rightarrow -+NP$	A_{10}	
$S \rightarrow I+R$	A_{11}	

TABLE 28

Observed Frequencies of Types of Statements without Verbs in each Section of the Corpus

Type	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
K	101	30	131	88	15	103	54	15	69	303
VM+K	9	38	47	5	43	48	5	29	34	129
VM+K+VM	1	1	2	0	1	1	2	0	2	5
VM	2	8	10	15	40	55	26	45	71	136
NP+VM	0	0	0	1	4	5	2	12	14	19
NP	25	5	30	31	14	45	33	17	50	125
-+NP	0	4	4	7	2	9	0	0	0	13
Z	0	0	0	40	0	40	77	17	94	134
Z+Z	0	0	0	22	0	22	18	9	27	49
Z+Z+Z	0	0	0	13	0	13	1	1	2	15
A	4	0	4	3	0	3	4	0	4	11
A+K	1	0	1	3	0	3	2	1	3	7
VM+A	0	0	0	0	2	2	0	7	7	9
NBR	0	0	0	0	7	7	0	0	0	7
NBR+NBR	0	0	0	0	6	6	0	0	0	6
NBR+NBR+NBR	0	4	4	0	0	0	1	0	1	5
NP+C+NP	0	3	3	0	0	0	3	0	3	6
R	0	0	0	4	7	11	7	9	16	27
R+R	0	3	3	4	7	11	3	1	4	18
I+R	0	1	1	0	6	6	0	3	3	10
R+K	0	7	7	7	11	18	8	15	23	48
R+VM	0	0	0	3	2	5	0	0	0	5

TABLE 29

Percent of each Section of the Corpus Accounted for by the Grammar for Statements without Verbs

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
96.6	92.0	94.6	98.4	89.8	94.7	96.1	92.4	94.5	94.6

TABLE 30

Maximum-likelihood Estimates for the Entire Corpus for the Grammar for Statements without Verbs

Parameter	Value
A[1]	.2787
A[2]	.2438
A[3]	.0166
A[4]	.0690
A[5]	.1380
A[6]	.1822
A[7]	.0166
A[8]	.0129
A[9]	.0212
A[10]	.0120
A[11]	.0092
B1[1]	.5140
B1[2]	.4860
B2[1]	.0400
B2[2]	.1267
B2[3]	.8333
B3[1]	.2546
B3[2]	.0926
B3[3]	.6528
B4[1]	.6429
B4[2]	.3571
B5[1]	.7826
B5[2]	.2174

TABLE 31

Observed and Expected Frequencies, Chi-square Contributions, and Total Chi-square for the Entire Corpus for the Grammar for Statements without Verbs

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  303     303.0      .0   K
  129     136.2      .4   VM+K
    5       5.0      .0   VM+K+VM
  136     128.8      .4   VM
   19      19.0      .0   NP+VM
  125     125.0      .0   NP
   13      13.0      .0   -+NP
  134     129.2      .2   Z
   49      50.4      .0   Z+Z
   15      18.3      .6   Z+Z+Z
   11       8.7      .6   A
    7       9.3      .5   A+K
    9       9.0      .0   VM+A
    7      11.8     1.9   NBR
    6       4.6           NBR+NBR
    5       1.7           NBR+NBR+NBR

   11       6.3     3.6   EXPECTED FREQ. LESS THAN 5.0

    6       6.0      .0   NP+C+NP
   27      36.5     2.5   R
   18      18.0      .0   R+R
   10      10.0      .0   I+R
   48      38.5     2.3   R+K
    5       5.0      .0   R+VM


    0      -.0            RESIDUAL

 1087    1087.0    13.0   TOTAL

              3           DEGREES OF FREEDOM
```

The analysis shows that the grammar for statements without verbs provides a very good fit, comparable to that of the verbal modifier grammar. Figure 4 provides further indication of this fit.

Insert Figure 4 about here

The observed frequencies given in Table 28 show some interesting differences in the two reading series. The Scott-Foresman series introduces number words and counting in the pre-primer and continues usage of this vocabulary in the primer; the Ginn series does not introduce number words either as adjectives or for use in counting until the reader. The Ginn series makes much more use of sounds, for example "Zoom, zoom." and "Mew, mew.", than the Scott-Foresman series. The Ginn series also makes more use of noun phrases standing alone.

Grammar for Interrogatives

The grammar for interrogatives is presented in Table 32. The grammar includes eight rewrite rules and a transformation with several parts. The grammar generates 22 syntactic types and uses 15 parameters; thus, if no collapsing were necessary, the model would have 6 degrees of freedom. Note that parameters $B2_1$ and $B2_2$ were used for a choice of "K" or "VM" whether the choice occurred at the end of an interrogative which was an inversion of a statement or an interrogative which used an interrogative pronoun.

Insert Table 32 about here

Subscripts are used to insure that the noun in the subjective position and the verb agree in number and person; a third subscript is attached to each noun-phrase entry to indicate the required case (subjective or objective) of the noun. Of course, the person and case subscripts effect a change in terminal vocabulary only in case the noun phrase is a pronoun. Number and person subscripts have been attached to the noun phrases in the objective positions even though there is no verb with which they must agree. This was to avoid confusion in subscript order, and to correspond to the notation in the final grammar for statements with verbs. In that grammar such subscripts are necessary in the transformations. In the tables showing the statistical analysis of this grammar, only the case subscripts have been indicated; these are necessary to clarify the

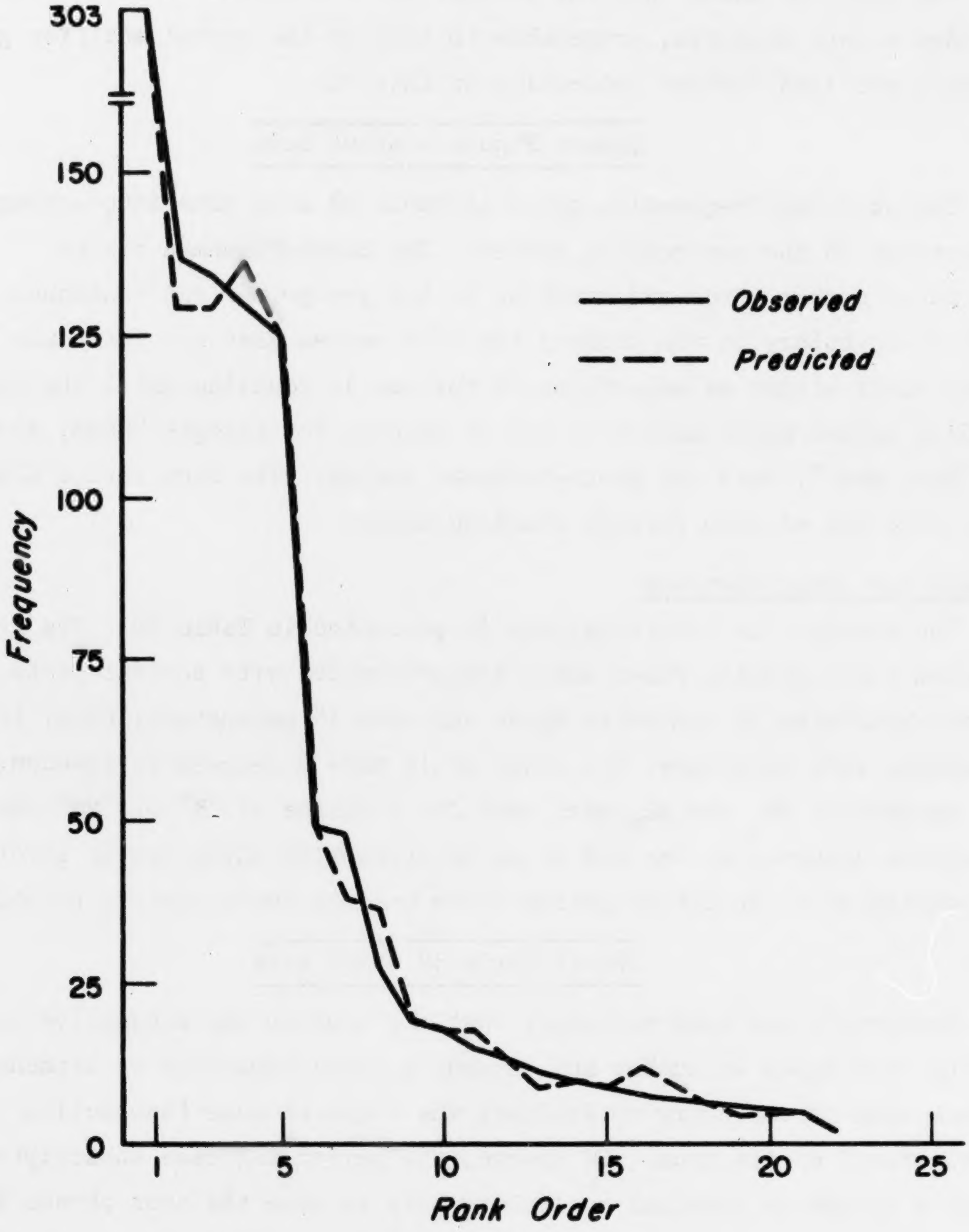

Fig. 4. Comparison of observed and predicted frequencies for statements without verbs (entire corpus).

TABLE 32

The Grammar for Interrogatives

Rewrite Rules	Parameters	
	Rule-Choice Probabilities	Within-Rule-Choice Probabilities
Inversions of Statements:		
$Q \rightarrow M_{i,j}+NP_{i,j,1}+\left(\begin{Bmatrix} VP_3 \\ VP_3+NP_{k,\ell,2} \end{Bmatrix}\right)+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$	A_1	$B1_1$ $B2_1$ $B1_2$ $B2_2$ $B1_3$ $B2_3$
$Q \rightarrow M_{i,j}+NP_{i,j,1}+VP_3+O+VP_3+\begin{Bmatrix} NP_{k,\ell,2} \\ VM \end{Bmatrix}$	A_2	$B3_1$ $B3_2$
$Q \rightarrow M_{i,j}+NP_{i,j,1}+VP_3+NP_{k,\ell,2}+NP_{m,n,1}+VP_{m,n}$	A_3	
$Q \rightarrow M_{i,j}+NP_{i,j,1}+VP_3+A+K$	A_4	
Use of Interrogative Pronoun, Adverb, or Adjective:		
$Q \rightarrow IP_{i,j,1}+VP_{i,j}+(O+VP_3)+VM$	A_5	$B4_1$ $B4_2$
$Q \rightarrow IP_{i,j,2}+M_{i,j}+NP_{k,\ell,1}+VP_3+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$	A_6	$B2_1$ $B2_2$ $B2_3$
$Q \rightarrow IADV+M_{i,j}+NP_{i,j,1}+VP_3+\begin{Bmatrix} NP_{k,\ell,2} \\ VM \end{Bmatrix}$	A_7	$B5_1$ $B5_2$ $B5_3$
$Q \rightarrow IADJ+NP_{k,\ell,2}+M_{i,j}+NP_{i,j,1}+VP_3$	A_8	

in $NP_{i,j,k}$: $i = 1,2$ = number
$j = 1,2,3$ = person
$k = 1,2$ = case

in $VP_{i,j}$: i = number
$j = 1,2,3$ = person

$VP_3 \Rightarrow$ infinitive form (verbs lacking infinitive form may not be used)

Obligatory Transformations:

If $M_{i,j}$ is a form of "to be" or "to do", and VP_3 is "be", then:

a. $M_{i,j}+NP_{i,j,1}+VP_3+(NP_{k,\ell,2})+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right) \rightarrow VP_{i,j}+NP_{i,j,1}+(NP_{k,\ell,1})+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$

b. $M_{i,j}+NP_{i,j,1}+VP_3+NP_{k,\ell,2}+NP_{m,n,1}+VP_{m,n} \rightarrow VP_{i,j}+NP_{i,j,1}+NP_{k,\ell,1}+NP_{m,n,1}+VP_{m,n}$

c. $M_{i,j}+NP_{i,j,1}+VP_3+A+K \rightarrow VP_{i,j}+NP_{i,j,1}+A+K$

d. $IP_2+M_{i,j}+NP_{i,j,1}+VP_3+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right) \rightarrow IP_1+VP_{i,j}+NP_{i,j,1}+\left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$

e. $IADV+M_{i,j}+NP_{i,j,1}+VP_3+(NP_{k,\ell,2})+(VM) \rightarrow IADV+VP_{i,j}+NP_{i,j,1}+(NP_{k,\ell,1})+(VM)$

f. $IADJ+NP_{k,\ell,2}+M_{i,j}+NP_{i,j,1}+VP_3 \rightarrow IADJ+NP_{k,\ell,1}+VP_{i,j}+NP_{i,j,1}$

type involved, but the other subscripts should be apparent as they are specifically dictated by the grammar.

The transformations were necessary for sentences involving the verb "to be". They change such sentences as "Is that be (being) the book I wanted?" and "Why are you be (being) the one in the corner?" to "Is that the book I wanted?" and "Why are you the one in the corner?"

Note that transformation (a) makes it possible to derive interrogatives involving the verb "to be" with no modal in two ways. Such statements (for example, "Is she here?") can be derived from the first rewrite rule either by choosing "$M_{i,j}$" to be "is" and deleting the first set of choices, or by choosing "$M_{i,j}$" to be "is" and "VP_3" to be "be" in which case the transformation would produce the desired form. For purposes of analysis it was assumed that the direct route would be taken. This seemed a logical assumption since the transformation is mainly a safety device in case "to be" verbs are accidently chosen for both the modal and the main verb.

Like the previous two grammars, a large number of zero and low frequencies for the individual sections made separate analyses meaningless. Table 33 shows the observed frequencies for the individual sections, Table 34 shows the percent of each section of the corpus accounted for by the grammar, and Tables 35 and 36 show the chi-square analysis for the corpus as a whole.

Insert Tables 33-36 about here

This grammar accounted for a smaller percent of the interrogatives in the corpus than the previous grammars did for their respective parts of the corpus. The interrogatives were fewer in number and much more irregular than the other types which have been analyzed. The interrogative grammar generates one type, $(M_{i,j}+NP_{i,j,l}+K)$, which is not in the corpus. An example of a sentence of this type is "May I, Mother?" which is not an unusual English sentence. This type is derivable from the first rewrite rule from which "May I?" and "May I go, Mother?" can also be derived. Interrogatives of these latter types are found in the corpus, and so the type $(M_{i,j}+NP_{i,j,l}+K)$ seemed to be within the framework of the implied grammar. To have constructed the grammar so that that type was not derivable would have required a much more complicated grammar and more parameters.

TABLE 33

Observed Frequencies of Interrogative Types in each Section of the Corpus

Type	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
M+NP(1)	0	1	1	1	0	1	0	1	1	3
M+NP(1)+VP	1	1	2	1	1	2	0	3	3	7
M+NP(1)+VP+NP(2)	1	9	10	8	8	16	12	4	16	42
M+NP(1)+K	0	0	0	0	0	0	0	0	0	0
M+NP(1)+VP+K	1	0	1	1	0	1	0	0	0	2
M+NP(1)+VP+NP(2)+K	2	0	2	1	1	2	3	1	4	8
M+NP(1)+VM	5	2	7	5	1	6	2	1	3	16
M+NP(1)+VP+VM	1	3	4	8	5	13	8	3	11	28
M+NP(1)+VP+NP(2)+VM	5	1	6	7	6	13	4	2	6	25
M+NP(1)+VP+O+VP+NP(2)	0	0	0	2	1	3	0	0	0	3
M+NP(1)+VP+O+VP+VM	0	0	0	4	1	5	1	1	2	7
M+NP(1)+VP+NP(2)+NP(1)+VP	0	1	1	7	1	8	3	0	3	12
M+NP(1)+VP+A+K	0	0	0	1	0	1	2	0	2	3
IP(1)+VP+VM	0	0	0	3	0	3	3	3	6	9
IP(1)+VP+O+VP+VM	0	2	2	0	0	0	1	0	1	3
IP(2)+M+NP(1)+VP	3	7	10	17	5	22	13	7	20	52
IP(2)+M+NP(1)+VP+K	0	1	1	0	1	1	1	1	2	4
IP(2)+M+NP(1)+VP+VM	0	2	2	3	3	6	2	2	4	12
IADV+M+NP(1)+VP	0	0	0	8	6	14	5	5	10	24
IADV+M+NP(1)+VP+NP(2)	0	0	0	2	1	3	0	3	3	6
IADV+M+NP(1)+VP+VM	0	0	0	1	2	3	3	4	7	10
IADV+NP(2)+M+NP(1)+VP	0	0	0	3	1	4	1	0	1	5

TABLE 34

Percent of each Section of the Corpus Accounted for by the Grammar for Interrogatives

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
100	75.0	83.1	81.4	68.8	76.5	77.1	59.4	69.1	74.5

TABLE 35

Maximum-likelihood Estimates for the Entire Corpus for the Grammar for Interrogatives

Parameter	Value
A[1]	.4662
A[2]	.0356
A[3]	.0427
A[4]	.0107
A[5]	.0427
A[6]	.2420
A[7]	.1423
A[8]	.0178
B1[1]	.2824
B1[2]	.5725
B1[3]	.1450
B2[1]	.0704
B2[2]	.4070
B2[3]	.5226
B3[1]	.3000
B3[2]	.7000
B4[1]	.2500
B4[2]	.7500
B5[1]	.1500
B5[2]	.2500
B5[3]	.6000

TABLE 36

Observed and Expected Frequencies, Chi-square
Contributions, and Total Chi-square for the Entire Corpus
for the Grammar for Interrogatives

OBSERV.	EXPECT.	CHI**2	SOURCE
3	9.9	4.8	M+NP(1)
7	19.3	7.9	M+NP(1)+VP
42	39.2	.2	M+NP(1)+VP+NP(2)
0	1.3		M+NP(1)+K
2	2.6		M+NP(1)+VP+K
8	5.3	1.4	M+NP(1)+VP+NP(2)+K
16	7.7	8.8	M+NP(1)+VM
28	15.1	11.1	M+NP(1)+VP+VM
25	30.5	1.0	M+NP(1)+VP+NP(2)+VM
3	3.0		M+NP(1)+VP+O+VP+NP(2)
5	6.9	.5	EXPECTED FREQ. LESS THAN 5.0
7	7.0	.0	M+NP(1)+VP+O+VP+VM
12	12.0	.0	M+NP(1)+VP+NP(2)+NP(1)+VP
3	3.0		M+NP(1)+VP+A+K
9	9.0	.0	IP(1)+VP+VM
3	3.0		IP(1)+VP+O+VP+VM
6	6.0	.0	EXPECTED FREQ. LESS THAN 5.0
52	35.5	7.6	IP(2)+M+NP(1)+VP
4	4.8		IP(2)+M+NP(1)+VP+K
12	27.7	8.9	IP(2)+M+NP(1)+VP+VM
24	24.0	.0	IADV+M+NP(1)+VP
6	6.0	.0	IADV+M+NP(1)+VP+NP(2)
10	10.0	.0	IADV+M+NP(1)+VP+VM
5	5.0	.0	IADJ+NP(2)+M+NP(1)+VP
4	4.8		RESIDUAL
281	281.0	52.3	TOTAL
		2	DEGREES OF FREEDOM

Regarding the inclusion of unobserved types, it should be noted that in a probabilistic grammar the criterion of a grammar not generating utterances not found in the corpus is not as important as the criterion that the probabilities of such utterances be low. If the theoretical grammar includes but is not identical to the grammar (the actual grammatical types) of the corpus, a good probabilistic fit could be obtained, and there is no real need, once a probabilistic viewpoint is adopted for the two grammars to be identical. For the interrogative grammar the probability of the unobserved type is .005 which is sufficiently low.

The total chi-square shown in Table 36 indicates that this grammar is not as good as the verbal-modifier grammar or the statements-without-verbs grammar, but is better than the noun-phrase grammar which had a larger comparative chi-square and the same number of degrees of freedom. It is not significantly different from the verb-phrase grammar. Figure 5, however, shows that in terms of rank order the fit of this grammar is not as good as any of the previous grammars.

Insert Figure 5 about here

Compound Statements

A compound statement was defined to be any pair of statements derivable from the grammar for statements with verbs (next section) and connected by one of the words: "and", "but", or "so". ("Or" was not used as a conjunction in this corpus.) This definition includes such statements as "Jane ran home, but Spot did not go with her.", and "I want to stay here, and maybe I can." Imperatives such as "Run and help Mother." were considered simple statements with compound predicates; these are derivable from the grammar for statements with verbs and as such are not compound statements. Under the stated definition, the statement "Run and help Mother and take Spot with you." would have to be considered a compound statement, but such combinations did not occur.

The entire corpus contained only 86 compound statements, a total of 1.1% of the utterances. The syntactic types ranged in frequency from one to eight, the average being about four. The types were so dissimilar that any grammar would have been little more than a list of observed types; in addition, the low frequencies would have made any statistical analysis,

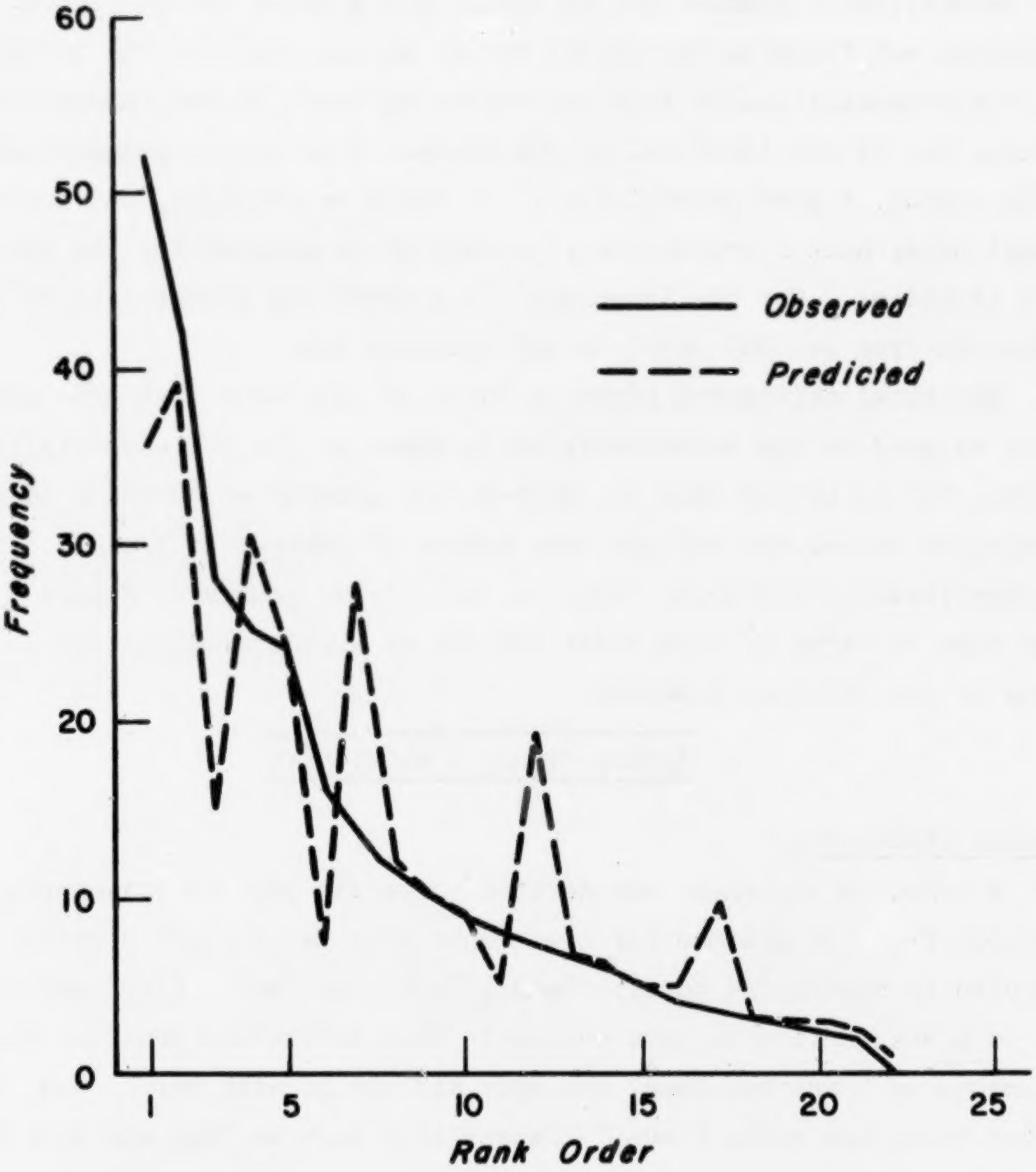

Fig. 5. Comparison of observed and predicted frequencies for interrogatives (entire corpus).

including one for the corpus as a whole, invalid. A grammar consisting of the statement with verb grammar with the option to connect any two generated types by "and", "but", or "so" would have generated far more types than were contained in the corpus; while the probabilities of the observed types would have been low, the probabilities of the observed types would also have been low (due to the low observed frequencies), and the result would be a very poor fit. Thus, it was decided that no grammar would be written for compound statements.

Grammar for Statements with Verbs

As would be expected this grammar is the most complicated; it generates 131 utterance types and uses 43 parameters. This would allow 87 degrees of freedom if no collapsing due to low predicted frequencies were necessary. The grammar is presented in Table 37; it contains 24 rewrite rules and five obligatory transformations.

Insert Table 37 about here

The rewrite rules for the statement grammar have been divided into three categories for reading convenience: 1) statements with simple subjects and predicates and without embedding, 2) statements with compound subjects or compound predicates and without embedding, and 3) statements with embedding. The rules for embedding generate three basic utterance types: embedded statements without adverbial or subordinate connectives such as "I can help mother do this." (rules 14-16), statements with infinitive phrases such as "I can help mother to do this." (rules 17-22), and statements with subordinate conjunctions such as "He did not know that Sally was ready." and "Tom did not know how to dance." (rules 23 and 24).

Subscripts have been used as they were in the grammar for interrogatives to insure that subjective nouns and verbs agree in number and person, and to indicate the case of nouns. For this grammar number and person subscripts attached to noun phrases in the objective case were needed for transformation 4 as well as to avoid confusion of subscript meaning.

Any choices which involved the same subphrases and occurred in relatively the same position in different rewrite rules were assigned the same parameters. For example, whenever the choice "(VM)" occurred after

TABLE 37

The Grammar for Statements with Verbs

Rewrite Rules	Parameters	
	Rule-Choice Probabilities	**Within-Rule-Choice Probabilities**
I. Statements with single subject, single predicate, and no embedding:		
1. $S \rightarrow \left(\begin{Bmatrix} C \\ VM \end{Bmatrix}\right) + NP_{i,j,1} + VP_{i,j} + NP_{k,\ell,2} + \left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$	A_1	$B1_1$ $B2_1$ $B1_2$ $B2_2$ $B1_3$ $B2_3$
2. $S \rightarrow \left(\begin{Bmatrix} R \\ C \\ VM \end{Bmatrix}\right) + NP_{i,j,1} + VP_{i,j} + (VM) + (K)$	A_2	$B3_1$ $B3_2$ $B4_1$ $B5_1$ $B3_3$ $B4_2$ $B5_2$ $B3_4$
3. $S \rightarrow (VM) + VP_{i,2} + NP_{k,\ell,2} + \left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$	A_3	$B2_1$ $B6_1$ $B2_2$ $B6_2$ $B2_3$
4. $S \rightarrow (VM) + VP_{i,2} + (VM) + (K)$	A_4	$B6_1$ $B4_1$ $B5_1$ $B6_2$ $B4_2$ $B5_2$
5. $S \rightarrow NP_{i,j,1} + VP_{i,j} + VM + NP_{k,\ell,2}$	A_5	
6. $S \rightarrow NP_{i,j,1} + VM + VP_{i,j} + VM$	A_6	
7. $S \rightarrow C + VM + NP_{i,j,1} + VP_{i,j}$	A_7	
8. $S \rightarrow NP_{i,j,1} + VP_{i,j} + (VM) + A + \left(\begin{Bmatrix} K \\ VM \end{Bmatrix}\right)$	A_{12}	$B2_1$ $B9_1$ $B2_2$ $B9_2$ $B2_3$
9. $S \rightarrow VP_{i,2} + VM + A + K$	A_{13}	

TABLE 37 (continued)

II.	Statements with compound subjects or compound predicates:				
10.	$S \rightarrow VP_{i,2}+C+VP_{i,2}+(NP_{k,\ell,2})+\left(\begin{Bmatrix}K\\VM\end{Bmatrix}\right)$	A_8		$B7_1$ $B7_2$	$B2_1$ $B2_2$ $B2_3$
11.	$S \rightarrow NP_{i,j,1}+VP_{i,j}+C+VP_{i,j}+(NP_{k,\ell,2})+(VM)$	A_9		$B7_1$ $B7_2$	$B4_1$ $B4_2$
12.	$S \rightarrow (VM)+NP_{i,j,1}+C+NP_{k,\ell,1}+VP_{2,\ell}+(NP_{m,n,2})+(VM)$	A_{10}	$B6_1$ $B6_2$	$B7_1$ $B7_2$	$B4_1$ $B4_2$
13.	$S \rightarrow (VM)+(NP_{i,j,1})+VP_{i,j}+NP_{k,\ell,2}+C+NP_{m,n,2}+(VM)$ where $j = 2$ if $NP_{i,j,1}$ is deleted	A_{11}	$B6_1$ $B6_2$	$B8_1$ $B8_2$	$B4_1$ $B4_2$
III.	Statements with embedding:				
14.	$S \rightarrow (VM)+(NP_{i,j,1})+VP_{i,j}+NP_{k,\ell,2}+VP_3+(VM)$ where $j = 2$ if $NP_{i,j,1}$ is deleted	A_{15}	$B6_1$ $B6_2$	$B8_1$ $B8_2$	$B4_1$ $B4_2$
15.	$S \rightarrow (NP_{i,j,1})+VP_{i,j}+NP_{k,\ell,2}+VP_3+NP_{m,n,2}+(VM)$ where $j = 2$ if $NP_{i,j,1}$ is deleted	A_{16}		$B8_1$ $B8_2$	$B4_1$ $B4_2$
16.	$S \rightarrow (NP_{i,j,1})+VP_{i,j}+\begin{Bmatrix}RP_{k,\ell,2}\\NP_{k,\ell,2}\end{Bmatrix}+NP_{m,n,1}+VP_{m,n}+\left(\begin{Bmatrix}O+VP_3\\VM\end{Bmatrix}\right)$ where $j = 2$ if $NP_{i,j,1}$ is deleted	A_{17}	$B8_1$ $B8_2$	$B10_1$ $B10_2$	$B11_1$ $B11_2$ $B11_3$
17.	$S \rightarrow (VM)+NP_{i,j,1}+VP_{i,j}+O+VP_3+(NP_{k,\ell,2})+(VM)$	A_{18}	$B6_1$ $B6_2$	$B7_1$ $B7_2$	$B4_1$ $B4_2$
18.	$S \rightarrow NP_{i,j,1}+VP_{i,j}+NP_{i,\ell,2}+O+VP_3+\left(\begin{Bmatrix}NP_{m,n,2}\\NP_{m,n,2}+VP_3\end{Bmatrix}\right)+(VM)$	A_{19}		$B12_1$ $B12_2$ $B12_3$	$B4_1$ $B4_2$
19.	$S \rightarrow NP_{i,j,1}+C+NP_{k,\ell,1}+VP_{2,\ell}+O+VP_3+VM$	A_{20}			
20.	$S \rightarrow NP_{i,j,1}+VP_{i,j}+VM+O+VP_3$	A_{21}			
21.	$S \rightarrow NP_{i,j,1}+VP_{i,j}+O+VP_3+NP_{k,\ell,2}+VP_3$	A_{22}			
22.	$S \rightarrow NP_{i,j,1}+VP_{i,j}+A+O+VP_3+(VM)$	A_{14}			$B4_1$ $B4_2$

TABLE 37 (continued)

23. $S \rightarrow NP_{i,j,1}+VP_{i,j}+CON+O+VP_3$ A_{23}

$B13_1$

24. $S \rightarrow NP_{i,j,1}+VP_{i,j}+(NP_{k,\ell,2})+(VM)+CON+NP_{m,n,1}+$ A_{24} $B7_1$ $B4_1$ $B13_2$
$B7_2$ $B4_2$ $B13_3$

$$\left(\begin{Bmatrix} VP_{m,n} \\ VP_{m,n}+VM \end{Bmatrix}\right)$$

in $NP_{i,j,k}$ = i = 1,2 = number
j = 1,2,3 = person
k = 1,2 = case

in $VP_{i,j}$ = i = 1,2 = number
j = 1,2,3 = person

VP_3 => infinitive form (verbs lacking infinitive form may not be used)

Obligatory transformations:

1. If "VM" is an adverbial phrase of location or direction (for example: here, up, away, then up, off to the store), or if "VM" is one of these descriptions: "hippity-hop", "faster and faster", "swish", "swish, swish", "hop, hop", "splash, splash", "left foot first", "right foot first", and if "$VP_{i,j}$" is a form of "to be" or one of these verbs of locomotion: "walk", "jump", "go", "run", "come", "roll", "buzz", and if $NP_{i,j,1} \neq P$, then

$$(C)+VM+NP_{i,j,1}+VP_{i,j}+\ldots \rightarrow (C)+VM+VP_{i,j}+NP_{i,j,1}+\ldots$$

2. If "VM" is "so" and "$VP_{i,j}$" is a form of "to be" or "to do", or is: "can", "could", "may", "will", "shall", or "must", then

$$VM+NP_{i,j,1}+VP_{i,j} \rightarrow VM+VP_{i,j}+NP_{i,j,1}$$

3. If "$VP_{i,j}$" is a form of "to be", then

$$\ldots+VP_{i,j}+NP_{k,\ell,2}+\ldots \rightarrow \ldots+VP_{i,j}+NP_{k,\ell,1}+\ldots$$

4. If "$NP_{i,j,1}$" is "what + NP", then

$$\ldots+NP_{i,j,1}+VP_{i,j,1}+NP_{k,\ell,2}+\ldots \rightarrow \ldots+NP_{k,\ell,2}+NP_{i,j,1}+VP_{i,j}+\ldots$$

5. If "$VP_{i,j}$" is a form of: "to wish", "to think", "to say", "to guess", or "to know", then

$$\ldots+NP_{i,j,1}+VP_{i,j}+NP_{k,\ell,2}+VP_3+\ldots \rightarrow \ldots+NP_{i,j,1}+VP_{i,j}+NP_{k,\ell,1}+VP_{k,\ell}+\ldots$$

the main verb (rules 2, 4, 11, 12, 13, 14, 15, 17, 18, 22, and 24), the parameters $B4_1$ (probability of accepting) and $B4_2$ (provability of deleting) were assigned; whenever the choice "(VM)" occurred before the main verb (rules 3, 4, 12, 13, 14, and 17), the parameters $B6_1$ (probability of accepting) and $B6_2$ (probability of deleting) were assigned. Parameter notation in Table 37 is the same as has been used previously; if two or more sets of parameters which sum to one are necessary for the same rule, the first vertical column of within-choice parameters contains probabilities for the first (left-most) set of choices in the rule, the second column contains probabilities for the second set of choices, etc.

In certain instances inversions of the form specified by the rules regularly occurred. For example "Here comes Sally." was used instead of "Here Sally comes.", and "Away ran Dick." was used instead of "Away Dick ran." The first transformation specifies exactly when these inversions occur; the adverbial phrase is usually one of location or direction ("here", "up", "off to the store"), the verb is a form of "to be" or a verb of locomotion ("run", "come"), and the noun phrase is something other than a pronoun. The structure "Here he comes." is always used rather than "Here comes he." The second transformation handles a second type of inversion; it changes expressions like "So I can." into "So can I."

The third transformation changes the noun in the objective case following a form of "to be" into the subjective case; for example, it would change "That is him." into "That is he." The fourth transformation would change an utterance like "That is what a pretty dress." into "What a pretty dress that is." Note that a noun phrase of the form "what + NP" was derivable from the noun-phrase grammar by deriving (T+A+...+N), choosing the first "A" to be "what", and applying an obligatory transformation. The last transformation changes the verb of an embedded utterance following a verb of thought or observation from the infinitive form to a form which agrees in number and person with the subject of the embedded clause. For example, it would change "I think he want to come." into "I think he wants to come."

The statistics for this grammar are presented in Tables 38 through 42. The recurring problem of zero and low frequency types made a chi-square analysis for the Ginn pre-primer and the Scott-Foresman pre-primer invalid, but all other sections of the corpus including the pre-primers combined were analyzed. The observed frequencies for the Ginn and Scott-Foresman pre-primers are given in Table 38.

Insert Tables 38-42 about here

The grammar accounts for 85.5% of all statements with verbs in the corpus as a whole. In each of the three major sections (the pre-primers, the primers, and the readers) a greater precent of the Ginn utterances than the Scott-Foresman utterances were derivable from the grammar. The Scott-Foresman books contain a greater variety of utterance types and display more irregularity of syntactic pattern than the Ginn books.

This grammar generated some types which did not appear in the corpus as can be seen from the observed frequencies for the entire corpus in Table 42. However the probabilities of such types are low (the largest is .003) and, as has been explained previously, from a probabilistic viewpoint this is completely acceptable.

The degrees of freedom available for each section of the corpus were sufficiently different to require F-tests for purposes of comparison. These tests showed no significant difference in fit among sections with the exception of the pre-primers combined which had a significantly poorer fit. The pre-primers combined had a large number of zero or low frequency types and very few degrees of freedom. There is no significant difference between the fit of the grammar to the Ginn series and the fit to the Scott-Foresman series, so the greater syntactic variety in the Scott-Foresman series implied by the comparative percents derivable from the grammar is due mainly to low frequency types not accounted for by the grammar.

The similarity of high frequency syntactic patterns in the two series is indicated in Table 43 which shows the ten highest frequency types of each section of each series.

Insert Table 43 about here

TABLE 38

Observed Frequencies of Types of Statements with Verbs in Sections not Included in the Analysis

TYPE	GINN PRE-PRIMER	S-F PRE-PRIMER
NP(1)+VP+NP(2)	75	69
NP(1)+VP+NP(2)+K	3	1
NP(1)+VP+NP(2)+VM	20	24
C+NP(1)+VP+NP(2)	0	6
C+NP(1)+VP+NP(2)+K	0	0
C+NP(1)+VP+NP(2)+VM	0	3
VM+NP(1)+VP+NP(2)	0	0
VM+NP(1)+VP+NP(2)+K	0	0
VM+NP(1)+VP+NP(2)+VM	0	0
NP(1)+VP	14	20
NP(1)+VP+VM	44	31
NP(1)+VP+K	1	0
NP(1)+VP+VM+K	2	0
R+NP(1)+VP	0	0
R+NP(1)+VP+VM	0	0
R+NP(1)+VP+K	0	0
R+NP(1)+VP+VM+K	0	0
C+NP(1)+VP	0	0
C+NP(1)+VP+VM	0	3
C+NP(1)+VP+K	0	0
C+NP(1)+VP+VM+K	0	0
VM+NP(1)+VP	41	21
VM+NP(1)+VP+VM	14	6
VM+NP(1)+VP+K	4	1
VM+NP(1)+VP+VM+K	0	0
VP+NP(2)	62	16
VP+NP(2)+K	23	0
VP+NP(2)+VM	13	2
VM+VP+NP(2)	0	0
VM+VP+NP(2)+K	0	0
VM+VP+NP(2)+VM	0	0
VP	6	18

TABLE 38 (continued)

Type	Ginn Pre-Primer	S-F Pre-Primer
VP+ VM	24	58
VP+ VM+ K	59	35
VM+ VP+ VM+ K	0	1
VP+K	63	27
VM+ VP+ K	0	0
VM+ VP	0	1
VM+ VP+ VM	0	2
NP (1)+ VP+ VM+ NP (2)	0	0
NP (1)+ VM+ VP+ VM	0	0
C+ VM+ NP(1) + VP	1	0
VP+C+ VP	24	1
VP+C+ VP+ NP (2)	42	4
VP+C+ VP+ VM	5	2
VP+C+ VP+K	5	0
VP+C+ VP+ NP (2)+ VM	1	2
VP+C+ VP+ NP (2)+K	2	0
NP (1)+ VP+C+ VP	0	2
NP (1)+ VP+C+ VP+ NP (2)	1	0
NP (1)+ VP+C+ VP+ VM	0	0
NP (1)+ VP+C+ VP+ NP (2)+ VM	0	0
NP (1)+C+ NP (1)+ VP	4	1
NP (1)+C+ NP (1)+ VP+ NP(2)	0	3
NP (1)+C+ NP (1)+ VP+ NP(2)+ VM	0	0
NP (1)+C+ NP (1)+ VP+ VM	1	1
VM+ NP (1)+C+ NP (1)+ VP	1	0
VM+ NP (1)+C+ NP (1)+ VP+ NP (2)	0	0
VM+ NP (1)+C+ NP (1)+ VP+ NP (2)+ VM	0	0
VM+ NP (1)+C+ NP (1)+ VP+ VM	0	0
VP+ NP (2)+C+ NP (2)	11	2
VP+ NP (2)+C+ NP (2)+ VM	0	0
NP (1)+ VP+ NP(2)+C+ NP(2)	3	5
NP (1)+ VP+ NP(2)+C+ NP(2)+ VM	0	0
VM+ VP+ NP (2)+C+ NP (2)	0	0
VM+ VP+ NP (2)+C+ NP (2)+ VM	0	0
VM+ NP (1)+ VP+ NP (2)+C+ NP (2)	0	0
VM+ NP (1)+ VP+ NP (2)+C+ NP (2)+ VM	0	0

TABLE 38 (continued)

Type	Ginn Pre-Primer	S-F Pre-Primer
NP(1)+VP+A	6	2
NP(1)+VP+VM+A	0	0
NP(1)+VP+A+K	1	0
NP(1)+VP+VM+A+K	0	0
NP(1)+VP+A+VM	0	0
NP(1)+VP+VM+A+VM	0	0
VP+VM+A+K	0	0
NP(1)+VP+A+O+VP	0	0
NP(1)+VP+A+O+VP+VM	0	0
VP+NP(2)+VP	16	1
VP+NP(2)+VP+VM	8	2
NP(1)+VP+NP(2)+VP	0	1
NP(1)+VP+NP(2)+VP+VM	1	1
VM+VP+NP(2)+VP	0	0
VM+VP+NP(2)+VP+VM	0	0
VM+NP(1)+VP+NP(2)+VP	0	0
VM+NP(1)+VP+NP(2)+VP+VM	0	0
VP+NP(2)+VP+NP(2)	4	4
VP+NP(2)+VP+NP(2)+VM	0	0
NP(1)+VP+NP(2)+VP+NP(2)	1	0
NP(1)+VP+NP(2)+VP+NP(2)+VM	0	0
VP+NP(2)+NP(1)+VP	2	2
VP+NP(2)+NP(1)+VP+VM	1	1
VP+NP(2)+NP(1)+VP+O+VP	0	0
NP(1)+VP+NP(2)+NP(1)+VP	8	6
NP(1)+VP+NP(2)+NP(1)+VP+VM	0	1
NP(1)+VP+NP(2)+NP(1)+VP+O+VP	0	0
VP+RP(2)+NP(1)+VP	0	0
VP+RP(2)+NP(1)+VP+VM	0	0
VP+RP(2)+NP(1)+VP+O+VP	0	0
NP(1)+VP+RP(2)+NP(1)+VP	0	0
NP(1)+VP+RP(2)+NP(1)+VP+VM	0	0
NP(1)+VP+RP(2)+NP(1)+VP+O+VP	0	0
NP(1)+VP+O+VP	10	6
NP(1)+VP+O+VP+NP(2)	9	8
NP(1)+VP+O+VP+NP(2)+VM	0	1

TABLE 38 (contined)

Type	Ginn Pre-Primer	S-F Pre-Primer
NP(1)+VP+0+VP+VM	12	7
VM+NP(1)+VP+0+VP	0	1
VM+NP(1)+VP+0+VP+NP(2)	0	0
VM+NP(1)+VP+0+VP+NP(2)+VM	0	0
VM+NP(1)+VP+0+VP+VM	0	0
NP(1)+VP+NP(2)+0+VP	1	1
NP(1)+VP+NP(2)+0+VP+NP(2)	0	5
NP(1)+VP+NP(2)+0+VP+NP(2)+VP	0	0
NP(1)+VP+NP(2)+0+VP+VM	0	5
NP(1)+VP+NP(2)+0+VP+NP(2)+VM	0	0
NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM	0	0
NP(1)+C+NP(1)+VP+0+VP+VM	0	0
NP(1)+VP+VM+0+VP	0	0
NP(1)+VP+0+VP+NP(2)+VP	0	0
NP(1)+VP+CON+0+VP	0	0
NP(1)+VP+CON+NP(1)	0	0
NP(1)+VP+CON+NP(1)+VP	0	0
NP(1)+VP+CON+NP(1)+VP+VM	0	0
NP(1)+VP+NP(2)+CON+NP(1)	0	0
NP(1)+VP+NP(2)+CON+NP(1)+VP	0	0
NP(1)+VP+NP(2)+CON+NP(1)+VP+VM	0	0
NP(1)+VP+VM+CON+NP(1)	0	0
NP(1)+VP+VM+CON+NP(1)+VP	0	0
NP(1)+VP+VM+CON+NP(1)+VP+VM	0	0
NP(1)+VP+NP(2)+VM+CON+NP(1)	0	0
NP(1)+VP+NP(2)+VM+CON+NP(1)+VP	0	0
NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM	0	0

TABLE 39

Percent of each Section of the Corpus Accounted for by the Grammar for Statements with Verbs

Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
93.9	87.4	91.2	90.6	83.5	87.5	88.5	72.6	81.8	85.5

TABLE 40

Maximum-Likelihood Estimate's for Sections of the Corpus Included in the Analysis for the Grammar for Statements with Verbs

Parameter	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
A[1]	.1875	.2735	.2579	.2670	.2913	.2778	.2862	.2582
A[2]	.1884	.2724	.2453	.2611	.3562	.3102	.3389	.2808
A[3]	.1082	.0291	.0425	.0347	.0216	.0240	.0225	.0454
A[4]	.2743	.1637	.1541	.1597	.1110	.0802	.0995	.1574
A[5]	.0000	.0000	.0000	.0000	.0029	.0108	.0059	.0027
A[6]	.0000	.0011	.0016	.0013	.0022	.0024	.0023	.0015
A[7]	.0009	.0011	.0000	.0007	.0043	.0012	.0032	.0019
A[8]	.0821	.0191	.0157	.0177	.0151	.0072	.0122	.0294
A[9]	.0028	.0135	.0126	.0131	.0115	.0132	.0122	.0104
A[10]	.0103	.0213	.0330	.0262	.0231	.0395	.0293	.0241
A[11]	.0196	.0045	.0142	.0085	.0130	.0108	.0122	.0127
A[12]	.0084	.0392	.0314	.0360	.0260	.0251	.0257	.0251
A[13]	.0000	.0000	.0000	.0000	.0029	.0012	.0023	.0010
A[14]	.0000	.0123	.0031	.0085	.0036	.0024	.0032	.0041
A[15]	.0280	.0314	.0236	.0281	.0187	.0311	.0234	.0259
A[16]	.0084	.0078	.0142	.0105	.0115	.0251	.0167	.0129
A[17]	.0196	.0314	.0283	.0301	.0130	.0108	.0122	.0195
A[18]	.0504	.0617	.0865	.0720	.0433	.0826	.0581	.0608
A[19]	.0112	.0135	.0267	.0190	.0079	.0216	.0131	.0145
A[20]	.0000	.0000	.0000	.0000	.0000	.0060	.0023	.0010
A[21]	.0000	.0000	.0000	.0000	.0036	.0000	.0023	.0010
A[22]	.0000	.0034	.0047	.0039	.0022	.0000	.0014	.0019
A[23]	.0000	.0000	.0000	.0000	.0036	.0000	.0023	.0010
A[24]	.0000	.0000	.0047	.0020	.0115	.0168	.0135	.0068
B1[1]	.0448	.0123	.0427	.0245	.0668	.1078	.0818	.0570
B1[2]	.0000	.0533	.1159	.0784	.1436	.1595	.1494	.1020
B1[3]	.9552	.9344	.8415	.8971	.7896	.7328	.7689	.8410
B2[1]	.0845	.0280	.0588	.0405	.0285	.0681	.0429	.0521
B2[2]	.1739	.2609	.3620	.3020	.3788	.4050	.3883	.3098
B2[3]	.7415	.7112	.5792	.6575	.5927	.5269	.5688	.6381
B3[1]	.0000	.0000	.0577	.0226	.0061	.0347	.0159	.0155
B3[2]	.0149	.0905	.0321	.0677	.0931	.0425	.0757	.0643
B3[3]	.4307	.3621	.3590	.3609	.3704	.4363	.3931	.3892
B3[4]	.5545	.5473	.5513	.5489	.5304	.4865	.5153	.5310
B4[1]	.5000	.5736	.6336	.5989	.6887	.6503	.6739	.6126
B4[2]	.5000	.4264	.3664	.4011	.3113	.3497	.3261	.3874
B5[1]	.3891	.1825	.1968	.1882	.1142	.0828	.1037	.1964
B5[2]	.6109	.8175	.8031	.8118	.8858	.9172	.8963	.8036
B6[1]	.0114	.0612	.1422	.0974	.1219	.2277	.1654	.0922
B6[2]	.9886	.9389	.8578	.9026	.8781	.7723	.8346	.9078
B7[1]	.4679	.4078	.4330	.4200	.4069	.3835	.3957	.4211
B7[2]	.5321	.5922	.5670	.5800	.5931	.6165	.6043	.5789
B8[1]	.3333	.5373	.4706	.5085	.6410	.7077	.6713	.5351
B8[2]	.6667	.4627	.5294	.4915	.3590	.2923	.3287	.4649
B9[1]	.0000	.0000	.3000	.1091	.3333	.1905	.2807	.1818
B9[2]	1.0000	.0000	.7000	.8909	.6667	.8095	.7193	.8182
B10[1]	.0000	.2143	.1111	.1739	.7222	.4444	.6296	.2660
B10[2]	1.0000	.7857	.8889	.8261	.2778	.5556	.3704	.7340
B11[1]	.0000	.0714	.0556	.0652	.1111	.1111	.1111	.0638
B11[2]	.1429	.1786	.1111	.1522	.1667	.3333	.2222	.1702
B11[3]	.8571	.7500	.8333	.7826	.7222	.5556	.6667	.7660
B12[1]	.4167	.5000	.4118	.4483	.1818	.3333	.2759	.3714
B12[2]	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
B12[3]	.5833	.5000	.5882	.5517	.8182	.6667	.7241	.6286
B13[1]	.0000	.0000	.6667	.6667	.4375	.2857	.3667	.3939
B13[2]	.0000	.0000	.3333	.3333	.0625	.3571	.2000	.2121
B13[3]	.0000	.0000	.0000	.0000	.5000	.3571	.4333	.3939

TABLE 41

Comparison of Total Chi-Squares for the Grammar for Statements with Verbs

Text	No. of Statements Accounted For	Total Chi-Square	Degrees of Freedom
Pre-Primers Combined	1072	364.7	2
Ginn Primer	892	249.6	8
Scott-Foresman Primer	636	254.2	7
Primers Combined	1528	478.3	26
Ginn Reader	1387	406.3	25
Scott-Foresman Reader	835	206.0	15
Readers Combined	2222	729.2	44
All Combined	4822	1644.0	61

TABLE 42

Observed and Expected Frequencies, Chi-Square Combinations, and Total Chi-Squares for each Section of the Corpus Included in the Analysis of the Grammar for Statements with Verbs

PRE-PRIMERS COMBINED

OBSERV.	EXPECT.	CHI**2	SOURCE
144	142.4	.0	NP(1)+VP+NP(2)
4	16.2	9.2	NP(1)+VP+NP(2)+K
44	33.4	3.4	NP(1)+VP+NP(2)+VM
6	6.7	.1	C+NP(1)+VP+NP(2)
0	.8		C+NP(1)+VP+NP(2)+K
3	1.6		C+NP(1)+VP+NP(2)+VM
0	.0		VM+NP(1)+VP+NP(2)
0	.0		VM+NP(1)+VP+NP(2)+K
0	.0		VM+NP(1)+VP+NP(2)+VM
34	34.2	.0	NP(1)+VP
75	34.2	48.6	NP(1)+VP+VM
1	21.8	19.8	NP(1)+VP+K
2	21.8	18.0	NP(1)+VP+VM+K
0	.0		R+NP(1)+VP
0	.0		R+NP(1)+VP+VM
0	.0		R+NP(1)+VP+K
0	.0		R+NP(1)+VP+VM+K
0	.9		C+NP(1)+VP
3	.9		C+NP(1)+VP+VM
0	.6		C+NP(1)+VP+K
0	.6		C+NP(1)+VP+VM+K
6	5.3	.1	EXPECTED FREQ. LESS THAN 5.0
62	26.6	47.2	VM+NP(1)+VP
20	26.6	1.6	VM+NP(1)+VP+VM
5	16.9	8.4	VM+NP(1)+VP+K
0	16.9	16.9	VM+NP(1)+VP+VM+K
78	85.0	.6	VP+NP(2)
23	9.7	18.3	VP+NP(2)+K
15	19.9	1.2	VP+NP(2)+VM
0	1.0		VM+VP+NP(2)
0	.1		VM+VP+NP(2)+K
0	.2		VM+VP+NP(2)+VM
24	88.8	47.3	VP
82	88.8	.5	VP+VM
94	56.5	24.8	VP+VM+K
1	.7		VM+VP+VM+K
90	56.5	19.8	VP+K
0	.7		VM+VP+K
1	1.0		VM+VP
2	1.0		VM+VP+VM
0	.0		NP(1)+VP+VM+NP(2)
0	.0		NP(1)+VM+VP+VM
1	1.0		C+VM+NP(1)+VP
5	5.7	.1	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

25	34.7	2.7	VP+C+VP
46	30.5	7.8	VP+C+VP+NP(2)
7	8.1	.2	VP+C+VP+VM
5	4.0		VP+C+VP+K
3	7.2	2.4	VP+C+VP+NP(2)+VM
2	3.5		VP+C+VP+NP(2)+K
7	7.4	.0	EXPECTED FREQ. LESS THAN 5.0
2	.8		NP(1)+VP+C+VP
1	.7		NP(1)+VP+C+VP+NP(2)
0	.8		VP(1)+VP+C+VP+VM
0	.7		NP(1)+VP+C+VP+NP(2)+VM
5	2.9		NP(1)+C+NP(1)+VP
8	5.9	.8	EXPECTED FREQ. LESS THAN 5.0
3	2.5		NP(1)+C+NP(1)+VP+NP(2)
0	2.5		NP(1)+C+NP(1)+VP+NP(2)+VM
3	5.1	.9	EXPECTED FREQ. LESS THAN 5.0
2	2.9		NP(1)+C+NP(1)+VP+VM
1	.0		VM+NP(1)+C+NP(1)+VP
0	.0		VM+NP(1)+C+NP(1)+VP+NP(2)
0	.0		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
0	.0		VM+NP(1)+C+NP(1)+VP+VM
13	6.9	5.3	VP+NP(2)+C+NP(2)
0	6.9	6.9	VP+NP(2)+C+NP(2)+VM
8	3.5		NP(1)+VP+NP(2)+C+NP(2)
11	6.5	3.2	EXPECTED FREQ. LESS THAN 5.0
0	3.5		NP(1)+VP+NP(2)+C+NP(2)+VM
0	.1		VM+VP+NP(2)+C+NP(2)
0	.1		VM+VP+NP(2)+C+NP(2)+VM
0	.0		VM+NP(1)+VP+NP(2)+C+NP(2)
0	.0		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
8	6.7	.3	NP(1)+VP+A
0	.0		NP(1)+VP+VM+A
1	.8		NP(1)+VP+A+K
0	.0		NP(1)+VP+VM+A+K
0	1.6		NP(1)+VP+A+VM
1	6.0	4.2	EXPECTED FREQ. LESS THAN 5.0
0	.0		NP(1)+VP+VM+A+VM
0	.0		VP+VM+A+K
0	.0		NP(1)+VP+A+O+VP
0	.0		NP(1)+VP+A+O+VP+VM
17	9.9	5.1	VP+NP(2)+VP
10	9.9	.0	VP+NP(2)+VP+VM
1	4.9		NP(1)+VP+NP(2)+VP

TABLE 42 (continued)

2	4.9		NP(1)+VP+NP(2)+VP+VM
3	9.9	4.8	EXPECTED FREQ. LESS THAN 5.0
0	.1		VM+VP+NP(2)+VP
0	.1		VM+VP+NP(2)+VP+VM
0	.1		VM+NP(1)+VP+NP(2)+VP
0	.1		VM+NP(1)+VP+NP(2)+VP+VM
8	3.0		VP+NP(2)+VP+NP(2)
0	3.0		VP+NP(2)+VP+NP(2)+VM
8	6.3	.4	EXPECTED FREQ. LESS THAN 5.0
1	1.5		NP(1)+VP+NP(2)+VP+NP(2)
0	1.5		NP(1)+VP+NP(2)+VP+NP(2)+VM
4	12.0	5.3	VP+NP(2)+NP(1)+VP
2	2.0		VP+NP(2)+NP(1)+VP+VM
3	5.0	.8	EXPECTED FREQ. LESS THAN 5.0
0	.0		VP+NP(2)+NP(1)+VP+0+VP
14	6.0	10.7	NP(1)+VP+NP(2)+NP(1)+VP
1	1.0		NP(1)+VP+NP(2)+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+NP(1)+VP+0+VP
0	.0		VP+RP(2)+NP(1)+VP
0	.0		VP+RP(2)+NP(1)+VP+VM
0	.0		VP+RP(2)+NP(1)+VP+0+VP
0	.0		NP(1)+VP+RP(2)+NP(1)+VP
0	.0		NP(1)+VP+RP(2)+NP(1)+VP+VM
0	.0		NP(1)+VP+RP(2)+NP(1)+VP+0+VP
16	14.2	.2	NP(1)+VP+0+VP
17	12.5	1.6	NP(1)+VP+0+VP+NP(2)
1	12.5	10.6	NP(1)+VP+0+VP+NP(2)+VM
19	14.2	1.6	NP(1)+VP+0+VP+VM
1	.2		VM+NP(1)+VP+0+VP
0	.1		VM+NP(1)+VP+0+VP+NP(2)
0	.1		VM+NP(1)+VP+0+VP+NP(2)+VM
0	.2		VM+NP(1)+VP+0+VP+VM
2	3.5		NP(1)+VP+NP(2)+0+VP
4	5.1	.2	EXPECTED FREQ. LESS THAN 5.0
5	2.5		NP(1)+VP+NP(2)+0+VP+NP(2)
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
5	3.5		NP(1)+VP+NP(2)+0+VP+VM
10	6.0	2.7	EXPECTED FREQ. LESS THAN 5.0
0	2.5		NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
0	.0		NP(1)+C+NP(1)+VP+0+VP+VM
0	.0		NP(1)+VP+VM+0+VP
0	.0		NP(1)+VP+0+VP+NP(2)+VP

TABLE 42 (continued)

0	.0		NP(1)+VP+CON+O+VP
0	.0		NP(1)+VP+CON+NP(1)
0	.0		NP(1)+VP+CON+NP(1)+VP
0	.0		NP(1)+VP+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+CON+NP(1)
0	.0		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.0		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+VM+CON+NP(1)
0	.0		NP(1)+VP+VM+CON+NP(1)+VP
0	.0		NP(1)+VP+VM+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+VM+CON+NP(1)
0	.0		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	.0		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
0	2.5		RESIDUAL
1072	1072.0	364.7	TOTAL
		2	DEGREES OF FREEDOM

TABLE 42 (continued)

GINN PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
161	162.2	.0	NP(1)+VP+NP(2)
5	6.4	.3	NP(1)+VP+NP(2)+K
62	59.5	.1	NP(1)+VP+NP(2)+VM
2	2.1		C+NP(1)+VP+NP(2)
0	.1		C+NP(1)+VP+NP(2)+K
1	.8		C+NP(1)+VP+NP(2)+VM
13	9.2	1.5	VM+NP(1)+VP+NP(2)
0	.4		VM+NP(1)+VP+NP(2)+K
0	3.4		VM+NP(1)+VP+NP(2)+VM
3	6.8	2.1	EXPECTED FREQ. LESS THAN 5.0
25	46.4	9.8	NP(1)+VP
106	62.4	30.5	NP(1)+VP+VM
1	10.4	8.4	NP(1)+VP+K
1	13.9	12.0	NP(1)+VP+VM+K
0	.0		R+NP(1)+VP
0	.0		R+NP(1)+VP+VM
0	.0		R+NP(1)+VP+K
0	.0		R+NP(1)+VP+VM+K
11	7.7	1.4	C+NP(1)+VP
10	10.3	.0	C+NP(1)+VP+VM
0	1.7		C+NP(1)+VP+K
1	2.3		C+NP(1)+VP+VM+K
58	30.7	24.3	VM+NP(1)+VP
26	41.3	5.6	VM+NP(1)+VP+VM
4	6.8	1.2	VM+NP(1)+VP+K
0	9.2	9.2	VM+NP(1)+VP+VM+K
18	17.4	.0	VP+NP(2)
1	.7		VP+NP(2)+K
5	6.4	.3	VP+NP(2)+VM
0	1.1		VM+VP+NP(2)
2	5.8	2.5	EXPECTED FREQ. LESS THAN 5.0
1	.0		VM+VP+NP(2)+K
1	.4		VM+VP+NP(2)+VM
13	47.8	25.3	VP
61	64.3	.2	VP+VM
32	14.3	21.7	VP+VM+K
1	.9		VM+VP+VM+K
28	10.7	28.2	VP+K
3	.7		VM+VP+K
1	3.1		VM+VP
7	5.2	.6	EXPECTED FREQ. LESS THAN 5.0
7	4.2		VM+VP+VM
0	.0		NP(1)+VP+VM+NP(2)

TABLE 42 (continued)

1	1.0		NP(1)+VM+VP+VM
8	5.2	1.5	EXPECTED FREQ. LESS THAN 5.0
1	1.0		C+VM+NP(1)+VP
1	7.2	5.3	VP+C+VP
12	4.9		VP+C+VP+NP(2)
13	5.9	8.4	EXPECTED FREQ. LESS THAN 5.0
4	2.6		VP+C+VP+VM
0	.3		VP+C+VP+K
0	1.8		VP+C+VP+NP(2)+VM
0	.2		VP+C+VP+NP(2)+K
8	3.0		NP(1)+VP+C+VP
12	7.9	2.1	EXPECTED FREQ. LESS THAN 5.0
0	2.1		NP(1)+VP+C+VP+NP(2)
3	4.1		VP(1)+VP+C+VP+VM
3	6.2	1.6	EXPECTED FREQ. LESS THAN 5.0
1	2.8		NP(1)+VP+C+VP+NP(2)+VM
1	4.5		NP(1)+C+NP(1)+VP
2	7.3	3.9	EXPECTED FREQ. LESS THAN 5.0
6	3.1		NP(1)+C+NP(1)+VP+NP(2)
1	4.2		NP(1)+C+NP(1)+VP+NP(2)+VM
7	7.3	.0	EXPECTED FREQ. LESS THAN 5.0
9	6.1	1.4	NP(1)+C+NP(1)+VP+VM
2	.3		VM+NP(1)+C+NP(1)+VP
0	.2		VM+NP(1)+C+NP(1)+VP+NP(2)
0	.3		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
0	.4		VM+NP(1)+C+NP(1)+VP+VM
1	.7		VP+NP(2)+C+NP(2)
0	1.0		VP+NP(2)+C+NP(2)+VM
3	.9		NP(1)+VP+NP(2)+C+NP(2)
0	1.2		NP(1)+VP+NP(2)+C+NP(2)+VM
0	.0		VM+VP+NP(2)+C+NP(2)
0	.1		VM+VP+NP(2)+C+NP(2)+VM
6	5.0	.2	EXPECTED FREQ. LESS THAN 5.0
0	.1		VM+NP(1)+VP+NP(2)+C+NP(2)
0	.1		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
22	24.9	.3	NP(1)+VP+A
0	.0		NP(1)+VP+VM+A
2	1.0		NP(1)+VP+A+K
0	.0		NP(1)+VP+VM+A+K

TABLE 42 (continued)

11	9.1	.4	NP(1)+VP+A+VM
0	.0		NP(1)+VP+VM+A+VM
0	.0		VP+VM+A+K
4	4.7		NP(1)+VP+A+0+VP
6	5.8	.0	EXPECTED FREQ. LESS THAN 5.0
7	6.3	.1	NP(1)+VP+A+0+VP+VM
11	5.2	6.5	VP+NP(2)+VP
4	7.0	1.3	VP+NP(2)+VP+VM
8	6.0	.6	NP(1)+VP+NP(2)+VP
5	8.1	1.2	NP(1)+VP+NP(2)+VP+VM
0	.3		VM+VP+NP(2)+VP
0	.5		VM+VP+NP(2)+VP+VM
0	.4		VM+NP(1)+VP+NP(2)+VP
0	.5		VM+NP(1)+VP+NP(2)+VP+VM
2	1.4		VP+NP(2)+VP+NP(2)
0	1.9		VP+NP(2)+VP+NP(2)+VM
4	1.6		NP(1)+VP+NP(2)+VP+NP(2)
6	6.6	.0	EXPECTED FREQ. LESS THAN 5.0
1	2.2		NP(1)+VP+NP(2)+VP+NP(2)+VM
9	7.6	.2	VP+NP(2)+NP(1)+VP
0	1.8		VP+NP(2)+NP(1)+VP+VM
0	.7		VP+NP(2)+NP(1)+VP+0+VP
12	8.9	1.1	NP(1)+VP+NP(2)+NP(1)+VP
1	2.1		NP(1)+VP+NP(2)+NP(1)+VP+VM
2	6.8	3.4	EXPECTED FREQ. LESS THAN 5.0
0	.8		NP(1)+VP+NP(2)+NP(1)+VP+0+VP
0	2.1		VP+RP(2)+NP(1)+VP
4	.5		VP+RP(2)+NP(1)+VP+VM
0	.2		VP+RP(2)+NP(1)+VP+0+VP
0	2.4		NP(1)+VP+RP(2)+NP(1)+VP
4	6.0	.7	EXPECTED FREQ. LESS THAN 5.0
0	.6		NP(1)+VP+RP(2)+NP(1)+VP+VM
2	.2		NP(1)+VP+RP(2)+NP(1)+VP+0+VP
6	13.0	3.8	NP(1)+VP+0+VP
17	9.0	7.2	NP(1)+VP+0+VP+NP(2)
4	12.1	5.4	NP(1)+VP+0+VP+NP(2)+VM
27	17.5	5.1	NP(1)+VP+0+VP+VM
0	.8		VM+NP(1)+VP+0+VP
1	.6		VM+NP(1)+VP+0+VP+NP(2)
0	.8		VM+NP(1)+VP+0+VP+NP(2)+VM
0	1.1		VM+NP(1)+VP+0+VP+VM
5	2.6		NP(1)+VP+NP(2)+0+VP
8	6.7	.2	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

```
  6      2.6             NP(1)+VP+NP(2)+O+VP+NP(2)
  0       .0             NP(1)+VP+NP(2)+O+VP+NP(2)+VP
  1      3.4             NP(1)+VP+NP(2)+O+VP+VM

  7      6.0       .2    EXPECTED FREQ. LESS THAN 5.0

  0      3.4             NP(1)+VP+NP(2)+O+VP+NP(2)+VM
  0       .0             NP(1)+VP+NP(2)+O+VP+NP(2)+VP+VM
  0       .0             NP(1)+C+NP(1)+VP+O+VP+VM
  0       .0             NP(1)+VP+VM+O+VP
  3      3.0             NP(1)+VP+O+VP+NP(2)+VP

  3      6.4      1.8    EXPECTED FREQ. LESS THAN 5.0

  0       .0             NP(1)+VP+CON+O+VP
  0       .0             NP(1)+VP+CON+NP(1)
  0       .0             NP(1)+VP+CON+NP(1)+VP
  0       .0             NP(1)+VP+CON+NP(1)+VP+VM
  0       .0             NP(1)+VP+NP(2)+CON+NP(1)
  0       .0             NP(1)+VP+NP(2)+CON+NP(1)+VP
  0       .0             NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
  0       .0             NP(1)+VP+VM+CON+NP(1)
  0       .0             NP(1)+VP+VM+CON+NP(1)+VP
  0       .0             NP(1)+VP+VM+CON+NP(1)+VP+VM
  0       .0             NP(1)+VP+NP(2)+VM+CON+NP(1)
  0       .0             NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
  0       .0             NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM

  0      -.0             RESIDUAL

892    892.0    249.6    TOTAL

                   8     DEGREES OF FREEDOM
```

TABLE 42 (continued)

SCOTT-FORESMAN PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
82	79.9	.1	NP(1)+VP+NP(2)
6	8.1	.6	NP(1)+VP+NP(2)+K
50	50.0	.0	NP(1)+VP+NP(2)+VM
4	4.1		C+NP(1)+VP+NP(2)
0	.4		C+NP(1)+VP+NP(2)+K
3	2.5		C+NP(1)+VP+NP(2)+VM
7	7.0	.0	EXPECTED FREQ. LESS THAN 5.0
18	11.0	4.4	VM+NP(1)+VP+NP(2)
0	1.1		VM+NP(1)+VP+NP(2)+K
1	6.9	5.0	VM+NP(1)+VP+NP(2)+VM
14	25.3	5.1	NP(1)+VP
72	43.8	18.2	NP(1)+VP+VM
0	6.2	6.2	NP(1)+VP+K
0	10.7	10.7	NP(1)+VP+VM+K
8	2.6		R+NP(1)+VP
1	4.6		R+NP(1)+VP+VM
9	8.3	.1	EXPECTED FREQ. LESS THAN 5.0
0	.6		R+NP(1)+VP+K
0	1.1		R+NP(1)+VP+VM+K
3	1.5		C+NP(1)+VP
2	2.5		C+NP(1)+VP+VM
5	5.8	.1	EXPECTED FREQ. LESS THAN 5.0
0	.4		C+NP(1)+VP+K
0	.6		C+NP(1)+VP+VM+K
33	16.5	16.6	VM+NP(1)+VP
21	28.5	2.0	VM+NP(1)+VP+VM
2	4.0		VM+NP(1)+VP+K
2	5.0	1.8	EXPECTED FREQ. LESS THAN 5.0
0	7.0	7.0	VM+NP(1)+VP+VM+K
8	13.4	2.2	VP+NP(2)
4	1.4		VP+NP(2)+K
6	8.4	.7	VP+NP(2)+VM
0	2.2		VM+VP+NP(2)
1	.2		VM+VP+NP(2)+K
8	1.4		VM+VP+NP(2)+VM
13	5.2	11.7	EXPECTED FREQ. LESS THAN 5.0
12	24.7	6.6	VP
35	42.8	1.4	VP+VM
41	10.5	88.8	VP+VM+K

TABLE 42 (continued)

1	1.7		VM+ VP+VM+ K
6	6.1	.0	VP+K
0	1.0		VM+ VP+K
0	4.1		VM+ VP
1	6.8	5.0	EXPECTED FREQ. LESS THAN 5.0
3	7.1	2.4	VM+ VP+ VM
0	.0		NP (1)+VP+ VM+ NP (2)
1	1.0		NP (1)+VM+ VP+VM
0	.0		C+VM+ NP (1)+VP
0	3.3		VP+C+ VP
2	2.5		VP+C+ VP+NP (2)
3	6.8	2.1	EXPECTED FREQ. LESS THAN 5.0
6	2.1		VP+C+ VP+VM
0	.3		VP+C+ VP+K
0	1.6		VP+C+ VP+ NP (2)+VM
2	.3		VP+C+ VP+NP (2)+K
4	1.7		NP (1)+VP+C+ VP
12	5.9	6.4	EXPECTED FREQ. LESS THAN 5.0
3	1.3		NP (1)+ VP+C+ VP+NP (2)
1	2.9		VP (1)+ VP+C+ VP+ VM
0	2.2		NP (1)+VP+C+ VP+NP (2)+VM
4	6.3	.9	EXPECTED FREQ. LESS THAN 5.0
0	3.7		NP (1)+C+ NP (1)+VP
2	2.9		NP (1)+C+NP (1)+VP+NP (2)
2	6.6	3.2	EXPECTED FREQ. LESS THAN 5.0
5	4.9		NP (1)+C+NP (1)+VP+NP (2)+VM
4	6.5	.9	NP (1)+C+NP (1)+VP+VM
6	.6		VM+NP (1)+C+NP (1)+VP
11	5.6	5.3	EXPECTED FREQ. LESS THAN 5.0
0	.5		VM+ NP (1)+C+NP (1)+VP+NP (2)
1	.8		VM+ NP (1)+C+NP (1)+VP+NP (2)+VM
3	1.1		VM+ NP (1)+C+NP (1)+VP+VM
1	1.5		VP+NP (2)+C+NP (2)
0	2.6		VP+NP (2)+C+NP (2)+VM
5	6.5	.3	EXPECTED FREQ. LESS THAN 5.0
5	1.3		NP (1)+VP+NP (2)+C+NP (2)
0	2.3		NP (1)+VP+NP (2)+C+NP (2)+VM
0	.2		VM+ VP+NP (2)+C+NP (2)
1	.4		VM+ VP+NP (2)+C+NP (2)+VM
2	.2		VM+ NP (1)+VP+NP (2)+C+NP (2)

TABLE 42 (continued)

0	.4		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
9	8.1	.1	NP(1)+VP+A
5	3.5		NP(1)+VP+VM+A
13	8.4	2.5	EXPECTED FREQ. LESS THAN 5.0
0	.8		NP(1)+VP+A+K
0	.4		NP(1)+VP+VM+A+K
5	5.1	.0	NP(1)+VP+A+VM
1	2.2		NP(1)+VP+VM+A+VM
0	.0		VP+VM+A+K
2	.7		NP(1)+VP+A+O+VP
0	1.3		NP(1)+VP+A+O+VP+VM
3	5.3	1.0	EXPECTED FREQ. LESS THAN 5.0
2	2.5		VP+NP(2)+VP
7	4.3		VP+NP(2)+VP+VM
9	6.8	.7	EXPECTED FREQ. LESS THAN 5.0
0	2.2		NP(1)+VP+NP(2)+VP
3	3.8		NP(1)+VP+NP(2)+VP+VM
3	6.1	1.5	EXPECTED FREQ. LESS THAN 5.0
0	.4		VM+VP+NP(2)+VP
0	.7		VM+VP+NP(2)+VP+VM
0	.4		VM+NP(1)+VP+NP(2)+VP
3	.6		VM+NP(1)+VP+NP(2)+VP+VM
2	1.7		VP+NP(2)+VP+NP(2)
5	3.0		VP+NP(2)+VP+NP(2)+VM
10	6.9	1.4	EXPECTED FREQ. LESS THAN 5.0
1	1.6		NP(1)+VP+NP(2)+VP+NP(2)
1	2.7		NP(1)+VP+NP(2)+VP+NP(2)+VM
8	7.1	.1	VP+NP(2)+NP(1)+VP
0	.9		VP+NP(2)+NP(1)+VP+VM
2	5.2	1.9	EXPECTED FREQ. LESS THAN 5.0
0	.5		VP+NP(2)+NP(1)+VP+O+VP
7	6.3	.1	NP(1)+VP+NP(2)+NP(1)+VP
0	.8		NP(1)+VP+NP(2)+NP(1)+VP+VM
1	.4		NP(1)+VP+NP(2)+NP(1)+VP+O+VP
0	.9		VP+RP(2)+NP(1)+VP
1	.1		VP+RP(2)+NP(1)+VP+VM
0	.1		VP+RP(2)+NP(1)+VP+O+VP
0	.8		NP(1)+VP+RP(2)+NP(1)+VP
1	.1		NP(1)+VP+RP(2)+NP(1)+VP+VM
0	.1		NP(1)+VP+RP(2)+NP(1)+VP+O+VP

TABLE 42 (continued)

3	9.8	4.7	NP(1)+VP+O+VP
17	7.5	12.1	NP(1)+VP+O+VP+NP(2)
9	12.9	1.2	NP(1)+VP+O+VP+NP(2)+VM
23	16.9	2.2	NP(1)+VP+O+VP+VM
1	1.6		VM+NP(1)+VP+O+VP
4	5.4	.3	EXPECTED FREQ. LESS THAN 5.0
1	1.2		VM+NP(1)+VP+O+VP+NP(2)
0	2.1		VM+NP(1)+VP+O+VP+NP(2)+VM
1	2.8		VM+NP(1)+VP+O+VP+VM
2	6.2	2.8	EXPECTED FREQ. LESS THAN 5.0
7	3.7		NP(1)+VP+NP(2)+O+VP
4	2.6		NP(1)+VP+NP(2)+O+VP+NP(2)
11	6.2	3.7	EXPECTED FREQ. LESS THAN 5.0
0	.0		NP(1)+VP+NP(2)+O+VP+NP(2)+VP
3	6.3	1.8	NP(1)+VP+NP(2)+O+VP+VM
3	4.4		NP(1)+VP+NP(2)+O+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+O+VP+NP(2)+VP+VM
0	.0		NP(1)+C+NP(1)+VP+O+VP+VM
0	.0		NP(1)+VP+VM+O+VP
3	3.0		NP(1)+VP+O+VP+NP(2)+VP
6	7.4	.3	EXPECTED FREQ. LESS THAN 5.0
0	.0		NP(1)+VP+CON+O+VP
0	.0		NP(1)+VP+CON+NP(1)
2	.4		NP(1)+VP+CON+NP(1)+VP
1	.2		NP(1)+VP+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+CON+NP(1)
0	.3		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.2		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+VM+CON+NP(1)
0	.7		NP(1)+VP+VM+CON+NP(1)+VP
0	.4		NP(1)+VP+VM+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+VM+CON+NP(1)
0	.5		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	.3		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
3	3.0		RESIDUAL
636	636.0	254.2	TOTAL
		7	DEGREES OF FREEDOM

TABLE 42 (continued)

PRIMERS COMBINED

OBSERV.	EXPECT.	CHI**2	SOURCE
243	240.6	.0	NP(1)+VP+NP(2)
11	14.8	1.0	NP(1)+VP+NP(2)+K
112	110.5	.0	NP(1)+VP+NP(2)+VM
6	6.6	.1	C+NP(1)+VP+NP(2)
0	.4		C+NP(1)+VP+NP(2)+K
4	3.0		C+NP(1)+VP+NP(2)+VM
31	21.0	4.7	VM+NP(1)+VP+NP(2)
0	1.3		VM+NP(1)+VP+NP(2)+K
1	9.7	7.8	VM+NP(1)+VP+NP(2)+VM
39	71.3	14.6	NP(1)+VP
178	106.5	48.0	NP(1)+VP+VM
1	16.5	14.6	NP(1)+VP+K
1	24.7	22.7	NP(1)+VP+VM+K
8	2.9		R+NP(1)+VP
12	7.7	2.5	EXPECTED FREQ. LESS THAN 5.0
1	4.4		R+NP(1)+VP+VM
0	.7		R+NP(1)+VP+K
1	5.1	3.3	EXPECTED FREQ. LESS THAN 5.0
0	1.0		R+NP(1)+VP+VM+K
14	8.8	3.1	C+NP(1)+VP
12	13.1	.1	C+NP(1)+VP+VM
0	2.0		C+NP(1)+VP+K
1	3.0		C+NP(1)+VP+VM+K
1	6.1	4.3	EXPECTED FREQ. LESS THAN 5.0
91	46.9	41.5	VM+NP(1)+VP
47	70.0	7.6	VM+NP(1)+VP+VM
6	10.9	2.2	VM+NP(1)+VP+K
0	16.2	16.2	VM+NP(1)+VP+VM+K
26	31.5	.9	VP+NP(2)
5	1.9		VP+NP(2)+K
11	14.4	.8	VP+NP(2)+VM
0	3.4		VM+VP+NP(2)
5	5.3	.0	EXPECTED FREQ. LESS THAN 5.0
2	.2		VM+VP+NP(2)+K
9	1.6		VM+VP+NP(2)+VM
25	71.7	30.4	VP
96	107.1	1.1	VP+VM
73	24.8	93.5	VP+VM+K
2	2.7		VM+VP+VM+K
34	16.6	18.2	VP+K
3	1.8		VM+VP+K

TABLE 42 (continued)

16	6.2	15.3	EXPECTED FREQ. LESS THAN 5.0
1	7.7	5.9	VM+VP
10	11.6	.2	VM+VP+VM
0	.0		NP(1)+VP+VM+NP(2)
2	2.0		NP(1)+VM+VP+VM
1	1.0		C+VM+NP(1)+VP
1	10.3	8.4	VP+C+VP
14	7.5	5.7	VP+C+VP+NP(2)
10	4.7		VP+C+VP+VM
13	7.7	3.6	EXPECTED FREQ. LESS THAN 5.0
0	.6		VP+C+VP+K
0	3.4		VP+C+VP+NP(2)+VM
2	.5		VP+C+VP+NP(2)+K
12	4.7		NP(1)+VP+C+VP
14	9.2	2.5	EXPECTED FREQ. LESS THAN 5.0
3	3.4		NP(1)+VP+C+VP+NP(2)
4	6.9	1.3	VP(1)+VP+C+VP+VM
1	5.0	3.2	NP(1)+VP+C+VP+NP(2)+VM
1	8.4	6.5	NP(1)+C+NP(1)+VP
8	6.1	.6	NP(1)+C+NP(1)+VP+NP(2)
6	9.1	1.0	NP(1)+C+NP(1)+VP+NP(2)+VM
13	12.5	.0	NP(1)+C+NP(1)+VP+VM
8	.9		VM+NP(1)+C+NP(1)+VP
0	.7		VM+NP(1)+C+NP(1)+VP+NP(2)
1	1.0		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
12	5.9	6.3	EXPECTED FREQ. LESS THAN 5.0
3	1.4		VM+NP(1)+C+NP(1)+VP+VM
2	2.3		VP+NP(2)+C+NP(2)
0	3.5		VP+NP(2)+C+NP(2)+VM
5	7.1	.6	EXPECTED FREQ. LESS THAN 5.0
8	2.4		NP(1)+VP+NP(2)+C+NP(2)
0	3.6		NP(1)+VP+NP(2)+C+NP(2)+VM
8	6.0	.7	EXPECTED FREQ. LESS THAN 5.0
0	.2		VM+VP+NP(2)+C+NP(2)
1	.4		VM+VP+NP(2)+C+NP(2)+VM
2	.3		VM+NP(1)+VP+NP(2)+C+NP(2)
0	.4		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
31	32.2	.0	NP(1)+VP+A
5	3.9		NP(1)+VP+VM+A
8	5.2	1.5	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

2	2.0		NP(1)+VP+A+K
0	.2		NP(1)+VP+VM+A+K
16	14.8	.1	NP(1)+VP+A+VM
1	1.8		NP(1)+VP+VM+A+VM
0	.0		VP+VM+A+K
6	5.2	.1	NP(1)+VP+A+O+VP
7	7.8	.1	NP(1)+VP+A+O+VP+VM
13	7.7	3.7	VP+NP(2)+VP
11	11.4	.0	VP+NP(2)+VP+VM
8	7.9	.0	NP(1)+VP+NP(2)+VP
8	11.8	1.2	NP(1)+VP+NP(2)+VP+VM
0	.8		VM+VP+NP(2)+VP
0	1.2		VM+VP+NP(2)+VP+VM
3	6.1	1.6	EXPECTED FREQ. LESS THAN 5.0
0	.9		VM+NP(1)+VP+NP(2)+VP
3	1.3		VM+NP(1)+VP+NP(2)+VP+VM
4	3.2		VP+NP(2)+VP+NP(2)
7	5.3	.6	EXPECTED FREQ. LESS THAN 5.0
5	4.7		VP+NP(2)+VP+NP(2)+VM
5	3.3		NP(1)+VP+NP(2)+VP+NP(2)
10	8.0	.5	EXPECTED FREQ. LESS THAN 5.0
2	4.9		NP(1)+VP+NP(2)+VP+NP(2)+VM
17	14.6	.4	VP+NP(2)+NP(1)+VP
0	2.8		VP+NP(2)+NP(1)+VP+VM
2	7.7	4.2	EXPECTED FREQ. LESS THAN 5.0
0	1.2		VP+NP(2)+NP(1)+VP+O+VP
19	15.1	1.0	NP(1)+VP+NP(2)+NP(1)+VP
1	2.9		NP(1)+VP+NP(2)+NP(1)+VP+VM
1	1.3		NP(1)+VP+NP(2)+NP(1)+VP+O+VP
2	5.4	2.2	EXPECTED FREQ. LESS THAN 5.0
0	3.1		VP+RP(2)+NP(1)+VP
5	.6		VP+RP(2)+NP(1)+VP+VM
0	.3		VP+RP(2)+NP(1)+VP+O+VP
0	3.2		NP(1)+VP+RP(2)+NP(1)+VP
5	7.1	.6	EXPECTED FREQ. LESS THAN 5.0
1	.6		NP(1)+VP+RP(2)+NP(1)+VP+VM
2	.3		NP(1)+VP+RP(2)+NP(1)+VP+O+VP
9	23.1	8.6	NP(1)+VP+O+VP
34	16.7	17.8	NP(1)+VP+O+VP+NP(2)
13	25.0	5.7	NP(1)+VP+O+VP+NP(2)+VM

TABLE 42 (continued)

50	34.5	7.0	NP(1)+VP+0+VP+VM
1	2.5		VM+NP(1)+VP+0+VP
2	1.8		VM+NP(1)+VP+0+VP+NP(2)
6	5.2	.1	EXPECTED FREQ. LESS THAN 5.0
0	2.7		VM+NP(1)+VP+0+VP+NP(2)+VM
1	3.7		VM+NP(1)+VP+0+VP+VM
1	6.4	4.6	EXPECTED FREQ. LESS THAN 5.0
12	6.4	4.9	NP(1)+VP+NP(2)+0+VP
10	5.2	4.4	NP(1)+VP+NP(2)+0+VP+NP(2)
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
4	9.6	3.3	NP(1)+VP+NP(2)+0+VP+VM
3	7.8	2.9	NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
0	.0		NP(1)+C+NP(1)+VP+0+VP+VM
0	.0		NP(1)+VP+VM+0+VP
6	6.0	.0	NP(1)+VP+0+VP+NP(2)+VP
0	.0		NP(1)+VP+CON+0+VP
0	.0		NP(1)+VP+CON+NP(1)
2	.5		NP(1)+VP+CON+NP(1)+VP
1	.2		NP(1)+VP+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+CON+NP(1)
0	.3		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.2		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+VM+CON+NP(1)
0	.7		NP(1)+VP+VM+CON+NP(1)+VP
0	.3		NP(1)+VP+VM+CON+NP(1)+VP+VM
0	.0		NP(1)+VP+NP(2)+VM+CON+NP(1)
0	.5		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	.3		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
3	3.0		RESIDUAL
1528	1528.0	478.3	TOTAL
		26	DEGREES OF FREEDOM

TABLE 42 (continued)

GINN READER

OBSERV.	EXPECT.	CHI**2	SOURCE
185	189.1	.1	NP(1)+VP+NP(2)
6	9.1	1.1	NP(1)+VP+NP(2)+K
128	120.8	.4	NP(1)+VP+NP(2)+VM
19	16.0	.6	C+NP(1)+VP+NP(2)
0	.8		C+NP(1)+VP+NP(2)+K
8	10.2	.5	C+NP(1)+VP+NP(2)+VM
36	34.4	.1	VM+NP(1)+VP+NP(2)
0	1.7		VM+NP(1)+VP+NP(2)+K
22	22.0	.0	VM+NP(1)+VP+NP(2)+VM
27	72.3	28.3	NP(1)+VP
231	159.8	31.7	NP(1)+VP+VM
1	9.3	7.4	NP(1)+VP+K
3	20.6	15.0	NP(1)+VP+VM+K
3	.8		R+NP(1)+VP
0	1.8		R+NP(1)+VP+VM
3	5.1	.9	EXPECTED FREQ. LESS THAN 5.0
0	.1		R+NP(1)+VP+K
0	.2		R+NP(1)+VP+VM+K
11	12.7	.2	C+NP(1)+VP
35	28.1	1.7	C+NP(1)+VP+VM
0	1.6		C+NP(1)+VP+K
0	3.6		C+NP(1)+VP+VM+K
0	5.6	5.6	EXPECTED FREQ. LESS THAN 5.0
76	50.5	12.9	VM+NP(1)+VP
100	111.6	1.2	VM+NP(1)+VP+VM
5	6.5	.3	VM+NP(1)+VP+K
2	14.4	10.7	VM+NP(1)+VP+VM+K
15	15.6	.0	VP+NP(2)
2	.8		VP+NP(2)+K
0	10.0	10.0	VP+NP(2)+VM
11	2.2		VM+VP+NP(2)
1	.1		VM+VP+NP(2)+K
1	1.4		VM+VP+NP(2)+VM
31	37.3	1.1	VP
51	82.5	12.0	VP+VM
38	10.6	70.4	VP+VM+K
0	1.5		VM+VP+VM+K
15	5.9	14.1	EXPECTED FREQ. LESS THAN 5.0
25	4.8		VP+K
0	.7		VM+VP+K
25	5.5	69.6	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

0	5.2	5.2	VM+ VP
9	11.4	.5	VM+ VP+VM
4	4.0		NP(1)+VP+VM+ NP(2)
3	3.0		NP(1)+VM+ VP+VM
7	7.0	.0	EXPECTED FREQ. LESS THAN 5.0
6	6.0	.0	C+ VM+ NP(1)+VP
2	7.4	3.9	VP+C+ VP
8	5.1	1.7	VP+C+ VP+NP(2)
7	4.7		VP+C+ VP+VM
3	.4		VP+C+ VP+K
10	5.1	4.8	EXPECTED FREQ. LESS THAN 5.0
0	3.2		VP+C+ VP+NP(2)+VM
1	.2		VP+C+ VP+NP(2)+K
7	3.0		NP(1)+VP+C+ VP
8	6.4	.4	EXPECTED FREQ. LESS THAN 5.0
6	2.0		NP(1)+ VP+C+ VP+NP(2)
3	6.5	1.9	VP(1)+ VP+C+ VP+VM
0	4.5		NP(1)+VP+C+ VP+NP(2)+VM
6	6.5	.0	EXPECTED FREQ. LESS THAN 5.0
2	5.2	2.0	NP(1)+C+ NP(1)+VP
3	3.6		NP(1)+C+ NP(1)+VP+NP(2)
3	7.9	3.0	NP(1)+C+NP(1)+VP+NP(2)+VM
16	11.5	1.8	NP(1)+C+ NP(1)+VP+VM
5	.7		VM+ NP(1)+C+ NP(1)+VP
1	.5		VM+ NP(1)+C+ NP(1)+VP+NP(2)
1	1.1		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
10	5.9	2.9	EXPECTED FREQ. LESS THAN 5.0
1	1.6		VM+ NP(1)+C+NP(1)+VP+VM
0	1.8		VP+NP(2)+C+ NP(2)
0	3.9		VP+ NP(2)+C+ NP(2)+VM
1	7.3	5.4	EXPECTED FREQ. LESS THAN 5.0
11	3.2		NP(1)+ VP+NP(2)+C+ NP(2)
4	7.0	1.3	NP(1)+VP+NP(2)+C+ NP(2)+VM
0	.2		VM+ VP+NP(2)+C+ NP(2)
0	.5		VM+ VP+NP(2)+C+NP(2)+VM
3	.4		VM+ NP(1)+VP+NP(2)+C+ NP(2)
0	1.0		VM+ NP(1)+VP+ NP(2)+C+ NP(2)+VM
14	5.3	14.0	EXPECTED FREQ. LESS THAN 5.0
13	14.2	.1	NP(1)+ VP+A

TABLE 42 (continued)

2	7.1	3.7	NP(1)+VP+VM+A
1	.7		NP(1)+VP+A+K
0	.3		NP(1)+VP+VM+A+K
10	9.1	.1	NP(1)+VP+A+VM
10	4.5		NP(1)+VP+VM+A+VM
11	5.6	5.3	EXPECTED FREQ. LESS THAN 5.0
4	4.0		VP+VM+A+K
0	1.6		NP(1)+VP+A+O+VP
4	5.6	.4	EXPECTED FREQ. LESS THAN 5.0
5	3.4		NP(1)+VP+A+O+VP+VM
6	2.6		VP+NP(2)+VP
11	6.0	4.2	EXPECTED FREQ. LESS THAN 5.0
8	5.6	1.0	VP+NP(2)+VP+VM
4	4.6		NP(1)+VP+NP(2)+VP
7	10.1	.9	NP(1)+VP+NP(2)+VP+VM
0	.4		VM+VP+NP(2)+VP
0	.8		VM+VP+NP(2)+VP+VM
4	5.7	.5	EXPECTED FREQ. LESS THAN 5.0
0	.6		VM+NP(1)+VP+NP(2)+VP
1	1.4		VM+NP(1)+VP+NP(2)+VP+VM
2	1.8		VP+NP(2)+VP+NP(2)
6	4.0		VP+NP(2)+VP+NP(2)+VM
9	7.8	.2	EXPECTED FREQ. LESS THAN 5.0
3	3.2		NP(1)+VP+NP(2)+VP+NP(2)
5	7.1	.6	NP(1)+VP+NP(2)+VP+NP(2)+VM
0	1.3		VP+NP(2)+NP(1)+VP
0	.3		VP+NP(2)+NP(1)+VP+VM
0	.2		VP+NP(2)+NP(1)+VP+O+VP
4	2.3		NP(1)+VP+NP(2)+NP(1)+VP
7	7.3	.0	EXPECTED FREQ. LESS THAN 5.0
1	.5		NP(1)+VP+NP(2)+NP(1)+VP+VM
0	.4		NP(1)+VP+NP(2)+NP(1)+VP+O+VP
4	3.4		VP+RP(2)+NP(1)+VP
2	.8		VP+RP(2)+NP(1)+VP+VM
7	5.0	.8	EXPECTED FREQ. LESS THAN 5.0
0	.5		VP+RP(2)+NP(1)+VP+O+VP
5	6.0	.2	NP(1)+VP+RP(2)+NP(1)+VP
0	1.4		NP(1)+VP+RP(2)+NP(1)+VP+VM
2	.9		NP(1)+VP+RP(2)+NP(1)+VP+O+VP

TABLE 42 (continued)

2	9.7	6.1	NP(1)+VP+0+VP
20	6.7	26.6	NP(1)+VP+0+VP+NP(2)
10	14.8	1.5	NP(1)+VP+0+VP+NP(2)+VM
23	21.5	.1	NP(1)+VP+0+VP+VM
1	1.4		VM+NP(1)+VP+0+VP
1	.9		VM+NP(1)+VP+0+VP+NP(2)
4	5.1	.2	EXPECTED FREQ. LESS THAN 5.0
0	2.0		VM+NP(1)+VP+0+VP+NP(2)+VM
3	3.0		VM+NP(1)+VP+0+VP+VM
3	5.0	.8	EXPECTED FREQ. LESS THAN 5.0
5	2.8		NP(1)+VP+NP(2)+0+VP
1	.6		NP(1)+VP+NP(2)+0+VP+NP(2)
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
4	6.2	.8	NP(1)+VP+NP(2)+0+VP+VM
1	1.4		NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
0	.0		NP(1)+C+NP(1)+VP+0+VP+VM
5	5.0	.0	NP(1)+VP+VM+0+VP
3	3.0		NP(1)+VP+0+VP+NP(2)+VP
10	7.8	.6	EXPECTED FREQ. LESS THAN 5.0
5	5.0	.0	NP(1)+VP+CON+0+VP
0	1.5		NP(1)+VP+CON+NP(1)
1	1.3		NP(1)+VP+CON+NP(1)+VP
1	.2		NP(1)+VP+CON+NP(1)+VP+VM
0	1.0		NP(1)+VP+NP(2)+CON+NP(1)
0	.9		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.1		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
3	3.3		NP(1)+VP+VM+CON+NP(1)
5	8.2	1.3	EXPECTED FREQ. LESS THAN 5.0
6	2.9		NP(1)+VP+VM+CON+NP(1)+VP
0	.4		NP(1)+VP+VM+CON+NP(1)+VP+VM
5	2.2		NP(1)+VP+NP(2)+VM+CON+NP(1)
11	5.5	5.5	EXPECTED FREQ. LESS THAN 5.0
0	2.0		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	.3		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
0	2.2		RESIDUAL
1387	1387.0	406.3	TOTAL
		25	DEGREES OF FREEDOM

TABLE 42 (continued)

SCOTT-FORESMAN READER

OBSERV.	EXPECT.	CHI**2	SOURCE
81	89.6	.8	NP(1)+VP+NP(2)
10	11.6	.2	NP(1)+VP+NP(2)+K
79	68.9	1.5	NP(1)+VP+NP(2)+VM
16	13.2	.6	C+NP(1)+VP+NP(2)
1	1.7		C+NP(1)+VP+NP(2)+K
8	10.1	.4	C+NP(1)+VP+NP(2)+VM
21	19.5	.1	VM+NP(1)+VP+NP(2)
1	2.5		VM+NP(1)+VP+NP(2)+K
15	15.0	.0	VM+NP(1)+VP+NP(2)+VM
8	40.4	26.0	NP(1)+VP
117	75.1	23.3	NP(1)+VP+VM
0	3.6		NP(1)+VP+K
2	7.9	4.4	EXPECTED FREQ. LESS THAN 5.0
1	6.8	4.9	NP(1)+VP+VM+K
9	2.9		R+NP(1)+VP
0	5.4	5.4	R+NP(1)+VP+VM
0	.3		R+NP(1)+VP+K
0	.5		R+NP(1)+VP+VM+K
1	3.5		C+NP(1)+VP
10	7.2	1.1	EXPECTED FREQ. LESS THAN 5.0
9	6.6	.9	C+NP(1)+VP+VM
0	.3		C+NP(1)+VP+K
1	.6		C+NP(1)+VP+VM+K
39	36.2	.2	VM+NP(1)+VP
73	67.4	.5	VM+NP(1)+VP+VM
1	3.3		VM+NP(1)+VP+K
0	6.1	6.1	VM+NP(1)+VP+VM+K
5	8.1	1.2	VP+NP(2)
4	1.1		VP+NP(2)+K
6	5.2	.1	EXPECTED FREQ. LESS THAN 5.0
1	6.3	4.4	VP+NP(2)+VM
7	2.4		VM+VP+NP(2)
0	.3		VM+VP+NP(2)+K
3	1.8		VM+VP+NP(2)+VM
15	16.6	.2	VP
24	30.9	1.5	VP+VM
16	2.8		VP+VM+K
26	7.3	47.4	EXPECTED FREQ. LESS THAN 5.0
0	.8		VM+VP+VM+K
7	1.5		VP+K
1	.4		VM+VP+K

TABLE 42 (continued)

2	4.9		VM+ VP
10	7.7	.7	EXPECTED FREQ. LESS THAN 5.0
2	9.1	5.5	VM+ VP+ VM
9	9.0	.0	NP(1)+ VP+ VM+ NP(2)
2	2.0		NP(1)+ VM+ VP+ VM
1	1.0		C+ VM+ NP(1)+ VP
0	1.9		VP+C+ VP
4	1.2		VP+C+ VP+NP(2)
7	6.2	.1	EXPECTED FREQ. LESS THAN 5.0
1	1.5		VP+C+ VP+ VM
0	.3		VP+C+ VP+K
0	.9		VP+C+ VP+NP(2)+VM
1	.2		VP+C+ VP+NP(2)+K
2	2.4		NP(1)+ VP+C+ VP
4	5.2	.3	EXPECTED FREQ. LESS THAN 5.0
3	1.5		NP(1)+VP+C+ VP+NP(2)
6	4.4		VP(1)+VP+C+ VP+VM
9	5.9	1.6	EXPECTED FREQ. LESS THAN 5.0
0	2.7		NP(1)+ VP+C+ VP+NP(2)+VM
2	5.5	2.2	NP(1)+C+ NP(1)+VP
5	3.4		NP(1)+C+NP(1)+VP+NP(2)
5	6.2	.2	EXPECTED FREQ. LESS THAN 5.0
3	6.4	1.8	NP(1)+C+NP(1)+VP+NP(2)+VM
8	10.2	.5	NP(1)+C+NP(1)+VP+VM
7	1.6		VM+ NP(1)+C+ NP(1)+ VP
3	1.0		VM+ NP(1)+C+ NP(1)+VP+NP(2)
0	1.9		VM+ NP(1)+C+ NP(1)+VP+NP(2)+VM
5	3.0		VM+ NP(1)+C+ NP(1)+VP+ VM
15	7.5	7.5	EXPECTED FREQ. LESS THAN 5.0
0	.7		VP+NP(2)+C+NP(2)
0	1.3		VP+NP(2)+C+ NP(2)+VM
6	1.7		NP(1)+VP+NP(2)+C+NP(2)
2	3.2		NP(1)+ VP+NP(2)+C+NP(2)+VM
8	7.0	.2	EXPECTED FREQ. LESS THAN 5.0
0	.2		VM+ VP+NP(2)+C+ NP(2)
0	.4		VM+ VP+NP(2)+C+ NP(2)+VM
1	.5		VM+ NP(1)+VP+ NP(2)+C+NP(2)
0	.9		VM+ NP(1)+ VP+ NP(2)+C+ NP(2)+VM
10	9.0	.1	NP(1)+VP+A

TABLE 42 (continued)

3	2.1		NP(1)+VP+VM+A
2	1.2		NP(1)+VP+A+K
6	5.3	.1	EXPECTED FREQ. LESS THAN 5.0
0	.3		NP(1)+VP+VM+A+K
5	6.9	.5	NP(1)+VP+A+VM
1	1.6		NP(1)+VP+VM+A+VM
1	1.0		VP+VM+A+K
1	.7		NP(1)+VP+A+O+VP
1	1.3		NP(1)+VP+A+O+VP+VM
6	2.1		VP+NP(2)+VP
10	6.9	1.3	EXPECTED FREQ. LESS THAN 5.0
3	3.8		VP+NP(2)+VP+VM
2	5.0		NP(1)+VP+NP(2)+VP
5	8.8	1.6	EXPECTED FREQ. LESS THAN 5.0
12	9.2	.8	NP(1)+VP+NP(2)+VP+VM
0	.6		VM+VP+NP(2)+VP
0	1.1		VM+VP+NP(2)+VP+VM
0	1.5		VM+NP(1)+VP+NP(2)+VP
3	2.7		VM+NP(1)+VP+NP(2)+VP+VM
3	5.9	1.4	EXPECTED FREQ. LESS THAN 5.0
4	2.1		VP+NP(2)+VP+NP(2)
4	4.0		VP+NP(2)+VP+NP(2)+VM
8	6.1	.6	EXPECTED FREQ. LESS THAN 5.0
6	5.2	.1	NP(1)+VP+NP(2)+VP+NP(2)
7	9.7	.7	NP(1)+VP+NP(2)+VP+NP(2)+VM
0	.8		VP+NP(2)+NP(1)+VP
0	.5		VP+NP(2)+NP(1)+VP+VM
0	.2		VP+NP(2)+NP(1)+VP+O+VP
2	2.0		NP(1)+VP+NP(2)+NP(1)+VP
2	1.2		NP(1)+VP+NP(2)+NP(1)+VP+VM
1	.4		NP(1)+VP+NP(2)+NP(1)+VP+O+VP
5	5.0	.0	EXPECTED FREQ. LESS THAN 5.0
1	.6		VP+RP(2)+NP(1)+VP
1	.4		VP+RP(2)+NP(1)+VP+VM
0	.1		VP+RP(2)+NP(1)+VP+O+VP
2	1.6		NP(1)+VP+RP(2)+NP(1)+VP
0	.9		NP(1)+VP+RP(2)+NP(1)+VP+VM
0	.3		NP(1)+VP+RP(2)+NP(1)+VP+O+VP
6	11.5	2.6	NP(1)+VP+O+VP
21	7.1	26.9	NP(1)+VP+O+VP+NP(2)
7	13.3	3.0	NP(1)+VP+O+VP+NP(2)+VM

TABLE 42 (continued)

18	21.4	.5	NP(1)+VP+0+VP+VM
6	3.4		VM+NP(1)+VP+0+VP
10	7.4	.9	EXPECTED FREQ. LESS THAN 5.0
4	2.1		VM+NP(1)+VP+0+VP+NP(2)
0	3.9		VM+NP(1)+VP+0+VP+NP(2)+VM
4	6.0	.7	EXPECTED FREQ. LESS THAN 5.0
7	6.3	.1	VM+NP(1)+VP+0+VP+VM
6	4.2		NP(1)+VP+NP(2)+0+VP
5	2.1		NP(1)+VP+NP(2)+0+VP+NP(2)
11	6.3	3.5	EXPECTED FREQ. LESS THAN 5.0
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
6	7.8	.4	NP(1)+VP+NP(2)+0+VP+VM
1	3.9		NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
5	5.0	.0	NP(1)+C+NP(1)+VP+0+VP+VM
0	.0		NP(1)+VP+VM+0+VP
0	.0		NP(1)+VP+0+VP+NP(2)+VP
0	.0		NP(1)+VP+CON+0+VP
0	1.1		NP(1)+VP+CON+NP(1)
2	.9		NP(1)+VP+CON+NP(1)+VP
3	5.8	1.4	EXPECTED FREQ. LESS THAN 5.0
4	1.1		NP(1)+VP+CON+NP(1)+VP+VM
0	.7		NP(1)+VP+NP(2)+CON+NP(1)
0	.5		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.7		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
5	2.0		NP(1)+VP+VM+CON+NP(1)
2	1.6		NP(1)+VP+VM+CON+NP(1)+VP
11	6.6	3.0	EXPECTED FREQ. LESS THAN 5.0
1	2.0		NP(1)+VP+VM+CON+NP(1)+VP+VM
0	1.2		NP(1)+VP+NP(2)+VM+CON+NP(1)
0	1.0		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	1.2		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
1	5.5	3.7	EXPECTED FREQ. LESS THAN 5.0
0	-.0		RESIDUAL
835	835.0	206.0	TOTAL
		15	DEGREES OF FREEDOM

TABLE 42 (continued)

READERS COMBINED

OBSERV.	EXPECT.	CHI**2	SOURCE
266	278.2	.5	NP(1)+VP+NP(2)
16	21.0	1.2	NP(1)+VP+NP(2)+K
207	189.9	1.5	NP(1)+VP+NP(2)+VM
35	29.6	1.0	C+NP(1)+VP+NP(2)
1	2.2		C+NP(1)+VP+NP(2)+K
16	20.2	.9	C+NP(1)+VP+NP(2)+VM
57	54.0	.2	VM+NP(1)+VP+NP(2)
1	4.1		VM+NP(1)+VP+NP(2)+K
2	6.3	2.9	EXPECTED FREQ. LESS THAN 5.0
37	36.9	.0	VM+NP(1)+VP+NP(2)+VM
35	113.4	54.2	NP(1)+VP
348	234.4	55.1	NP(1)+VP+VM
1	13.1	11.2	NP(1)+VP+K
4	27.1	19.7	NP(1)+VP+VM+K
12	3.5		R+NP(1)+VP
0	7.2	7.2	R+NP(1)+VP+VM
0	.4		R+NP(1)+VP+K
0	.8		R+NP(1)+VP+VM+K
12	16.7	1.3	C+NP(1)+VP
44	34.4	2.7	C+NP(1)+VP+VM
0	1.9		C+NP(1)+VP+K
12	6.7	4.2	EXPECTED FREQ. LESS THAN 5.0
1	4.0		C+NP(1)+VP+VM+K
115	86.5	9.4	VM+NP(1)+VP
173	178.8	.2	VM+NP(1)+VP+VM
6	10.0	1.6	VM+NP(1)+VP+K
2	20.7	16.9	VM+NP(1)+VP+VM+K
20	23.7	.6	VP+NP(2)
6	1.8		VP+NP(2)+K
7	5.8	.3	EXPECTED FREQ. LESS THAN 5.0
1	16.2	14.3	VP+NP(2)+VM
18	4.7		VM+VP+NP(2)
1	.4		VM+VP+NP(2)+K
19	5.1	38.4	EXPECTED FREQ. LESS THAN 5.0
4	3.2		VM+VP+NP(2)+VM
46	53.9	1.2	VP
75	111.4	11.9	VP+VM
54	12.9	131.1	VP+VM+K
0	2.6		VM+VP+VM+K
4	5.8	.5	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

32	6.2	106.4	VP+K
1	1.2		VM+ VP+K
2	10.7	7.1	VM+ VP
11	22.1	5.6	VM+ VP+VM
13	13.0	.0	NP(1)+VP+VM+NP(2)
5	5.0	.0	NP(1)+VM+VP+VM
7	7.0	.0	C+VM+NP(1)+VP
2	9.3	5.7	VP+C+VP
12	6.1	5.8	VP+C+VP+NP(2)
8	6.3	.4	VP+C+VP+VM
3	.7		VP+C+VP+K
0	4.1		VP+C+VP+NP(2)+VM
4	6.1	.7	EXPECTED FREQ. LESS THAN 5.0
2	.5		VP+C+VP+NP(2)+K
9	5.3	2.5	NP(1)+VP+C+VP
9	3.5		NP(1)+VP+C+VP+NP(2)
9	11.0	.4	VP(1)+VP+C+VP+VM
0	7.2	7.2	NP(1)+VP+C+VP+NP(2)+VM
4	10.7	4.2	NP(1)+C+NP(1)+VP
8	7.0	.1	NP(1)+C+NP(1)+VP+NP(2)
6	14.5	5.0	NP(1)+C+NP(1)+VP+NP(2)+VM
24	22.1	.2	NP(1)+C+NP(1)+VP+VM
12	2.1		VM+NP(1)+C+NP(1)+VP
23	6.1	47.3	EXPECTED FREQ. LESS THAN 5.0
4	1.4		VM+NP(1)+C+NP(1)+VP+NP(2)
1	2.9		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
6	4.4		VM+NP(1)+C+NP(1)+VP+VM
11	8.6	.6	EXPECTED FREQ. LESS THAN 5.0
0	2.4		VP+NP(2)+C+NP(2)
0	5.0		VP+NP(2)+C+NP(2)+VM
0	7.4	7.4	EXPECTED FREQ. LESS THAN 5.0
17	4.9		NP(1)+VP+NP(2)+C+NP(2)
6	10.2	1.7	NP(1)+VP+NP(2)+C+NP(2)+VM
0	.5		VM+VP+NP(2)+C+NP(2)
17	5.4	24.8	EXPECTED FREQ. LESS THAN 5.0
0	1.0		VM+VP+NP(2)+C+NP(2)+VM
4	1.0		VM+NP(1)+VP+NP(2)+C+NP(2)
0	2.0		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
23	23.3	.0	NP(1)+VP+A
5	9.1	1.8	NP(1)+VP+VM+A
3	1.8		NP(1)+VP+A+K

TABLE 42 (continued)

7	5.7	.3	EXPECTED FREQ. LESS THAN 5.0
0	.7		NP(1)+VP+VM+A+K
15	15.9	.1	NP(1)+VP+A+VM
11	6.2	3.7	NP(1)+VP+VM+A+VM
5	5.0	.0	VP+VM+A+K
1	2.3		NP(1)+VP+A+O+VP
6	4.7		NP(1)+VP+A+O+VP+VM
7	7.7	.1	EXPECTED FREQ. LESS THAN 5.0
12	4.7		VP+NP(2)+VP
11	9.6	.2	VP+NP(2)+VP+VM
6	9.5	1.3	NP(1)+VP+NP(2)+VP
19	19.6	.0	NP(1)+VP+NP(2)+VP+VM
0	.9		VM+VP+NP(2)+VP
12	5.6	7.4	EXPECTED FREQ. LESS THAN 5.0
0	1.9		VM+VP+NP(2)+VP+VM
0	1.9		VM+NP(1)+VP+NP(2)+VP
4	3.9		VM+NP(1)+VP+NP(2)+VP+VM
4	7.7	1.8	EXPECTED FREQ. LESS THAN 5.0
6	4.0		VP+NP(2)+VP+NP(2)
10	8.2	.4	VP+NP(2)+VP+NP(2)+VM
9	8.1	.1	NP(1)+VP+NP(2)+VP+NP(2)
12	16.7	1.3	NP(1)+VP+NP(2)+VP+NP(2)+VM
0	2.2		VP+NP(2)+NP(1)+VP
6	6.2	.0	EXPECTED FREQ. LESS THAN 5.0
0	.7		VP+NP(2)+NP(1)+VP+VM
0	.4		VP+NP(2)+NP(1)+VP+O+VP
6	4.5		NP(1)+VP+NP(2)+NP(1)+VP
6	5.6	.0	EXPECTED FREQ. LESS THAN 5.0
3	1.5		NP(1)+VP+NP(2)+NP(1)+VP+VM
1	.7		NP(1)+VP+NP(2)+NP(1)+VP+O+VP
5	3.7		VP+RP(2)+NP(1)+VP
9	6.0	1.5	EXPECTED FREQ. LESS THAN 5.0
3	1.2		VP+RP(2)+NP(1)+VP+VM
0	.6		VP+RP(2)+NP(1)+VP+O+VP
7	7.6	.0	NP(1)+VP+RP(2)+NP(1)+VP
0	2.5		NP(1)+VP+RP(2)+NP(1)+VP+VM
2	1.3		NP(1)+VP+RP(2)+NP(1)+VP+O+VP
5	5.7	.1	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

8	21.2	8.2	NP(1)+VP+0+VP
41	13.9	52.9	NP(1)+VP+0+VP+NP(2)
17	28.7	4.8	NP(1)+VP+0+VP+NP(2)+VM
41	43.8	.2	NP(1)+VP+0+VP+VM
7	4.2		VM+NP(1)+VP+0+VP
5	2.8		VM+NP(1)+VP+0+VP+NP(2)
12	7.0	3.7	EXPECTED FREQ. LESS THAN 5.0
0	5.7	5.7	VM+NP(1)+VP+0+VP+NP(2)+VM
10	8.7	.2	VM+NP(1)+VP+0+VP+VM
11	6.8	2.5	NP(1)+VP+NP(2)+0+VP
6	2.6		NP(1)+VP+NP(2)+0+VP+NP(2)
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
10	14.2	1.2	NP(1)+VP+NP(2)+0+VP+VM
2	5.4	2.1	NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
5	5.0	.0	NP(1)+C+NP(1)+VP+0+VP+VM
5	5.0	.0	NP(1)+VP+VM+0+VP
3	3.0		NP(1)+VP+0+VP+NP(2)+VP
9	5.6	2.1	EXPECTED FREQ. LESS THAN 5.0
5	5.0	.0	NP(1)+VP+CON+0+VP
0	2.6		NP(1)+VP+CON+NP(1)
3	2.2		NP(1)+VP+CON+NP(1)+VP
5	1.2		NP(1)+VP+CON+NP(1)+VP+VM
8	5.9	.7	EXPECTED FREQ. LESS THAN 5.0
0	1.7		NP(1)+VP+NP(2)+CON+NP(1)
0	1.4		NP(1)+VP+NP(2)+CON+NP(1)+VP
0	.8		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
8	5.3	1.4	NP(1)+VP+VM+CON+NP(1)
8	4.5		NP(1)+VP+VM+CON+NP(1)+VP
8	8.4	.0	EXPECTED FREQ. LESS THAN 5.0
1	2.4		NP(1)+VP+VM+CON+NP(1)+VP+VM
5	3.5		NP(1)+VP+NP(2)+VM+CON+NP(1)
6	5.9	.0	EXPECTED FREQ. LESS THAN 5.0
0	2.9		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
0	1.6		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
0	4.5		RESIDUAL
2222	2222.0	729.2	TOTAL
		44	DEGREES OF FREEDOM

TABLE 42 (continued)

```
         ALL COMBINED

OBSERV.  EXPECT.  CHI**2  SOURCE

  653     668.1      .3   NP(1)+VP+NP(2)
   31      54.6    10.2   NP(1)+VP+NP(2)+K
  363     324.3     4.6   NP(1)+VP+NP(2)+VM
   47      45.3      .1   C+NP(1)+VP+NP(2)
    1       3.7           C+NP(1)+VP+NP(2)+K
   23      22.0      .0   C+NP(1)+VP+NP(2)+VM
   88      81.0      .6   VM+NP(1)+VP+NP(2)
    1       6.6     4.8   VM+NP(1)+VP+NP(2)+K
   38      39.3      .0   VM+NP(1)+VP+NP(2)+VM
  108     223.8    59.9   NP(1)+VP
  601     354.0   172.4   NP(1)+VP+VM
    3      54.7    48.9   NP(1)+VP+K
    7      86.5    73.1   NP(1)+VP+VM+K
   20       6.5    27.7   R+NP(1)+VP
    1      10.3     8.4   R+NP(1)+VP+VM
    0       1.6           R+NP(1)+VP+K

    1       5.3     3.5   EXPECTED FREQ. LESS THAN 5.0

    0       2.5           R+NP(1)+VP+VM+K
   26      27.1      .0   C+NP(1)+VP
   59      42.8     6.1   C+NP(1)+VP+VM
    0       6.6     6.6   C+NP(1)+VP+K
    2      10.5     6.9   C+NP(1)+VP+VM+K
  268     164.0    65.9   VM+NP(1)+VP
  240     259.5     1.5   VM+NP(1)+VP+VM
   17      40.1    13.3   VM+NP(1)+VP+K
    2      63.4    59.5   VM+NP(1)+VP+VM+K
  124     126.9      .1   VP+NP(2)
   34      10.4    53.9   VP+NP(2)+K
   27      61.6    19.4   VP+NP(2)+VM
   18      12.9     2.0   VM+VP+NP(2)
    3       1.1           VM+VP+NP(2)+K
   13       6.3     7.3   VM+VP+NP(2)+VM
   95     214.5    66.6   VP
  253     339.2    21.9   VP+VM
  221      82.9   230.0   VP+VM+K
    3       8.4     3.5   VM+VP+VM+K
  156      52.4   204.7   VP+K
    4       5.3      .3   VM+VP+K
    4      21.8    14.5   VM+VP
   23      34.4     3.8   VM+VP+VM
   13      13.0      .0   NP(1)+VP+VM+NP(2)
    7       7.0      .0   NP(1)+VM+VP+VM
    9       9.0      .0   C+VM+NP(1)+VP

   28      52.5    11.4   VP+C+VP
   72      38.2    30.0   VP+C+VP+NP(2)
   25      25.5      .0   VP+C+VP+VM
```

TABLE 42 (continued)

8	4.3		VP+C+VP+K
11	7.9	1.3	EXPECTED FREQ. LESS THAN 5.0
3	18.5	13.0	VP+C+VP+NP(2)+VM
6	3.1		VP+C+VP+NP(2)+K
23	11.2	12.4	NP(1)+VP+C+VP
13	8.2	2.9	NP(1)+VP+C+VP+NP(2)
13	17.7	1.3	VP(1)+VP+C+VP+VM
1	12.9	11.0	NP(1)+VP+C+VP+NP(2)+VM
10	23.6	7.8	NP(1)+C+NP(1)+VP
19	17.2	.2	NP(1)+C+NP(1)+VP+NP(2)
12	27.2	8.5	NP(1)+C+NP(1)+VP+NP(2)+VM
39	37.3	.1	NP(1)+C+NP(1)+VP+VM
21	2.4		VM+NP(1)+C+NP(1)+VP
27	5.5	83.7	EXPECTED FREQ. LESS THAN 5.0
4	1.7		VM+NP(1)+C+NP(1)+VP+NP(2)
2	2.8		VM+NP(1)+C+NP(1)+VP+NP(2)+VM
9	3.8		VM+NP(1)+C+NP(1)+VP+VM
15	8.3	5.4	EXPECTED FREQ. LESS THAN 5.0
15	10.0	2.5	VP+NP(2)+C+NP(2)
0	15.8	15.8	VP+NP(2)+C+NP(2)+VM
33	11.5	40.4	NP(1)+VP+NP(2)+C+NP(2)
6	18.2	8.1	NP(1)+VP+NP(2)+C+NP(2)+VM
0	1.0		VM+VP+NP(2)+C+NP(2)
1	1.6		VM+VP+NP(2)+C+NP(2)+VM
6	1.2		VM+NP(1)+VP+NP(2)+C+NP(2)
0	1.8		VM+NP(1)+VP+NP(2)+C+NP(2)+VM
7	5.6	.3	EXPECTED FREQ. LESS THAN 5.0
62	63.2	.0	NP(1)+VP+A
10	14.0	1.2	NP(1)+VP+VM+A
6	5.2	.1	NP(1)+VP+A+K
0	1.1		NP(1)+VP+VM+A+K
31	30.7	.0	NP(1)+VP+A+VM
12	6.8	3.9	NP(1)+VP+VM+A+VM
5	5.0	.0	VP+VM+A+K
7	7.7	.1	NP(1)+VP+A+0+VP
13	12.3	.0	NP(1)+VP+A+0+VP+VM
42	20.4	22.8	VP+NP(2)+VP
32	32.3	.0	VP+NP(2)+VP+VM
15	23.5	3.1	NP(1)+VP+NP(2)+VP
29	37.2	1.8	NP(1)+VP+NP(2)+VP+VM
0	2.1		VM+VP+NP(2)+VP
0	3.3		VM+VP+NP(2)+VP+VM
0	6.5	6.5	EXPECTED FREQ. LESS THAN 5.0

TABLE 42 (continued)

0	2.4		VM+NP(1)+VP+NP(2)+VP
7	3.8		VM+NP(1)+VP+NP(2)+VP+VM
7	6.2	.1	EXPECTED FREQ. LESS THAN 5.0
18	11.2	4.2	VP+NP(2)+VP+NP(2)
15	17.7	.4	VP+NP(2)+VP+NP(2)+VM
15	12.9	.4	NP(1)+VP+NP(2)+VP+NP(2)
14	20.3	2.0	NP(1)+VP+NP(2)+VP+NP(2)+VM
21	24.6	.5	VP+NP(2)+NP(1)+VP
2	5.5	2.2	VP+NP(2)+NP(1)+VP+VM
0	2.0		VP+NP(2)+NP(1)+VP+0+VP
39	28.3	4.1	NP(1)+VP+NP(2)+NP(1)+VP
5	6.3	.3	NP(1)+VP+NP(2)+NP(1)+VP+VM
2	2.4		NP(1)+VP+NP(2)+NP(1)+VP+0+VP
5	8.9	1.7	VP+RP(2)+NP(1)+VP
8	2.0		VP+RP(2)+NP(1)+VP+VM
10	6.4	2.1	EXPECTED FREQ. LESS THAN 5.0
0	.7		VP+RP(2)+NP(1)+VP+0+VP
7	10.2	1.0	NP(1)+VP+RP(2)+NP(1)+VP
1	2.3		NP(1)+VP+RP(2)+NP(1)+VP+VM
4	.9		NP(1)+VP+RP(2)+NP(1)+VP+0+VP
33	59.6	11.9	NP(1)+VP+0+VP
92	43.4	54.5	NP(1)+VP+0+VP+NP(2)
31	68.6	20.6	NP(1)+VP+0+VP+NP(2)+VM
110	94.3	2.6	NP(1)+VP+0+VP+VM
9	6.1	1.4	VM+NP(1)+VP+0+VP
7	4.4		VM+NP(1)+VP+0+VP+NP(2)
12	8.3	1.7	EXPECTED FREQ. LESS THAN 5.0
0	7.0	7.0	VM+NP(1)+VP+0+VP+NP(2)+VM
11	9.6	.2	VM+NP(1)+VP+0+VP+VM
25	17.0	3.7	NP(1)+VP+NP(2)+0+VP
21	10.1	11.9	NP(1)+VP+NP(2)+0+VP+NP(2)
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP
19	27.0	2.3	NP(1)+VP+NP(2)+0+VP+VM
5	15.9	7.5	NP(1)+VP+NP(2)+0+VP+NP(2)+VM
0	.0		NP(1)+VP+NP(2)+0+VP+NP(2)+VP+VM
5	5.0	.0	NP(1)+C+NP(1)+VP+0+VP+VM
5	5.0	.0	NP(1)+VP+VM+0+VP
9	9.0	.0	NP(1)+VP+0+VP+NP(2)+VP
5	5.0	.0	NP(1)+VP+CON+0+VP
0	2.9		NP(1)+VP+CON+NP(1)
5	2.9		NP(1)+VP+CON+NP(1)+VP
5	5.8	.1	EXPECTED FREQ. LESS THAN 5.0
6	1.6		NP(1)+VP+CON+NP(1)+VP+VM
0	2.1		NP(1)+VP+NP(2)+CON+NP(1)
0	2.1		NP(1)+VP+NP(2)+CON+NP(1)+VP

TABLE 42 (continued)

6	5.8	.0	EXPECTED FREQ. LESS THAN 5.0
0	1.1		NP(1)+VP+NP(2)+CON+NP(1)+VP+VM
8	4.6		NP(1)+VP+VM+CON+NP(1)
8	5.8	.9	EXPECTED FREQ. LESS THAN 5.0
8	4.6		NP(1)+VP+VM+CON+NP(1)+VP
1	2.5		NP(1)+VP+VM+CON+NP(1)+VP+VM
9	7.1	.5	EXPECTED FREQ. LESS THAN 5.0
5	3.4		NP(1)+VP+NP(2)+VM+CON+NP(1)
0	3.4		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP
5	6.7	.4	EXPECTED FREQ. LESS THAN 5.0
0	1.8		NP(1)+VP+NP(2)+VM+CON+NP(1)+VP+VM
0	2.0		RESIDUAL
4822	4822.0	1644.0	TOTAL
		61	DEGREES OF FREEDOM

TABLE 43

Comparison of the High Frequency Types in the Ginn and Scott-Foresman Series

	Ginn Pre-Primer		Scott-Foresman Pre-Primer		Ginn Primer		Scott-Foresman Primer		Ginn Reader		Scott-Foresman Reader	
Rank	Type	Freq.	Type	Freq.	Type	Freq.	Type	Freq.	Type	Freq.	Type	Freq.
1	$NP_1+VP+NP_2$	75	$NP_1+VP+NP_2$	69	$NP_1+VP+NP_2$	161	$NP_1+VP+NP_2$	82	$NP_1+VP+VM$	231	$NP_1+VP+VM$	117
2	NP+K	63	VP+VM	58	$NP_1+VP+VM$	106	$NP_1+VP+VM$	72	$NP_1+VP+NP_2$	185	$NP_1+VP+NP_2$	81
3	$VP+NP_2$	62	VP+VM+K	35	$NP_1+VP+NP_2+VM$	62	$NP_1+VP+NP_2+VM$	50	$NP_1+VP+NP_2+VM$	128	$NP_1+VP+NP_2+VM$	79
4	VP+VM+K	59	$NP_1+VP+VM$	31	VP+VM	61	VP+VM+K	41	$VM+NP_1+VP+VM$	100	$VM+NP_1+VP+VM$	73
5	$NP_1+VP+VM$	44	VP+K	27	$VM+NP_1+VP$	58	VP+VM	35	$VM+NP_1+VP$	76	$VM+NP_1+VP$	39
6	$VP+C+VP+NP_2$	42	$NP_1+VP+NP_2+VM$	24	VP+VM+K	32	$VM+NP_1+VP$	33	VP+VM	51	VP+VM	24
7	VP+VM	24	$VM+NP_1+VP$	21	VP+K	28	$NP_1+VP+O+VP+VM$	23	VP+VM+K	38	$VM+NP_1+VP+NP_2$	21
8	VP+C+VP	24	NP_1+VP	20	$NP_1+VP+O+VP+VM$	27	$VM+NP_1+VP+VM$	21	$VM+NP_1+VP+NP_2$	36	$NP_1+VP+O+VP+NP_2$	21
9	$VP+NP_2+K$	23	VP	18	$VM+NP_1+VP+VM$	26	$VM+NP_1+VP+NP_2$	18	$C+NP_1+VP+VM$	35	$NP_1+VP+O+VP+VM$	18
10	$NP_1+VP+NP_2+VM$	20	$VP+NP_2$	16	NP_1+VP	25	$NP_1+VP+O+VP+NP_2$	17	VP	31	VP+VM+K	16

Within the pre-primers combined, seven of the ten highest ranking types of the Ginn series are among the ten highest ranking types of the Scott-Foresman series, and within the primers and readers eight of the ten highest ranking types are common to both. In the primers the first three high frequency types hold corresponding ranks in the Ginn and Scott-Foresman books, and in the readers the first six high frequency types hold corresponding ranks. The type $(NP_{i,j,1}+VP_{i,j}+NP_{k,\ell,2})$ is the most frequent pattern in the pre-primers and the primers and is the second most frequent pattern in the readers; in the readers the type $(NP_{i,j,1}+VP_{i,j}+VM)$ is most frequent. For all sections the majority of high frequency types can be generated from the rules for statements with simple subjects and predicates and without embedding.

The maximum-likelihood estimates for the rule choice parameters, A_1-A_{24}, indicate some changes in structural patterns from the pre-primers to the readers. Table 44 shows the rank order of the corresponding estimated values across sections; "1" indicates the largest value and "3" indicates the smallest.

Insert Table 44 about here

Within the statements without embedding there is a sharp decrease in the estimates for A_3, A_4, A_8, and A_{11} from the pre-primers to the readers. These are probabilities of statements which are (or in the case of A_{11} may be) imperatives, and include one and two word utterances such as "Run." and "Help Dick." The proportion of statements which include subjects or objects or both increases from the pre-primers to the readers, and with the exception of A_{15} the estimates for the probabilities of statements with embedding are smallest for the pre-primers. Again A_{15} is the parameter for a rule which may be an imperative. Estimates for $B8_1$ and $B8_2$, the parameters for including or deleting the subjective noun phrases, indicate that for the pre-primers the subject is deleted twice as often as not; thus when rule 13 with probability A_{11} or rule 14 with probability A_{15} is chosen for the pre-primers, the subjective noun phrase is usually deleted and the result is an imperative statement. Contrary to the Strickland finding and more in line with common-sense expectations, some evidence for a development of sentence structure was found in the

TABLE 44

Rank Order of the Maximum-Likelihood Estimates, A_1-A_{24}, across Sections of the Corpus

Parameter	Pre-Primers Combined	Primers Combined	Readers Combined
A_1	3	2	1
A_2	3	2	1
A_3	1	2	3
A_4	1	2	3
A_5	2.5	2.5	1
A_6	3	2	1
A_7	2	3	1
A_8	1	2	3
A_9	3	1	2
A_{10}	3	2	1
A_{11}	1	3	2
A_{12}	3	1	2
A_{13}	2.5	2.5	1
A_{14}	3	1	2
A_{15}	1.5	1.5	3
A_{16}	3	2	1
A_{17}	2	1	3
A_{18}	3	1	2
A_{19}	3	1	2
A_{20}	2.5	2.5	1
A_{21}	2.5	2.5	1
A_{22}	3	1	2
A_{23}	2.5	2.5	1
A_{24}	3	2	1

corpus; short statements without embedding were more probable in the pre-primers while longer statements and statements with embedding were more probable in the readers.

Table 42 indicates that a large percent of each of the total chi-squares is due to a few types which contribute very large chi-square values, rather than to many types with rather large chi-square contributions. For the corpus as a whole, for example, subtraction of the ten largest chi-square contributions yields a total chi-square of 573.7, a reduction of 1070.3 or 65.1%. Thus, in general, the grammar provided a good fit; again, however, the number of degrees of freedom is relatively small, and some sort of fit would be expected. Only one type, $(NP_{i,j,1}+VP_{i,j}+VM)$, was a consistently large contributer; predictions for this type were always too low. This type can be derived from the second rewrite rule; removing this possibility from the rule and forming instead a new rule in hopes of changing the parameters and providing a better fit for this type would involve changing the whole structure of the rule and including several more rules. This in turn might change some of the good predicted frequencies of other types derivable from the rule and in this way again increase the total chi-square value. Thus it seemed best to make no change in the grammar.

Figure 6 shows the fit of the grammar to the observed frequencies and their rank order. This indicates a fit which is poorer than the previous grammars for high frequency types but is in general quite good.

Insert Figure 6 about here

Table 45 summarizes the total chi-squares and the respective degrees of freedom for each of the six grammars for every section of the corpus in which the statistic was applicable. Table 46 shows the "average chi-squares" found by dividing the degrees of freedom into the total chi-square; these values form the numerators and denominators of the F-tests and make pairwise comparisons somewhat easier.

Insert Tables 45 and 46 about here

The fits given by the statements-with-verbs grammar for the primers individually and combined and for the Ginn reader were not significantly different than those given by the noun-phrase grammar for corresponding sections. The fit for the pre-primers combined was signficantly worse and the fits for

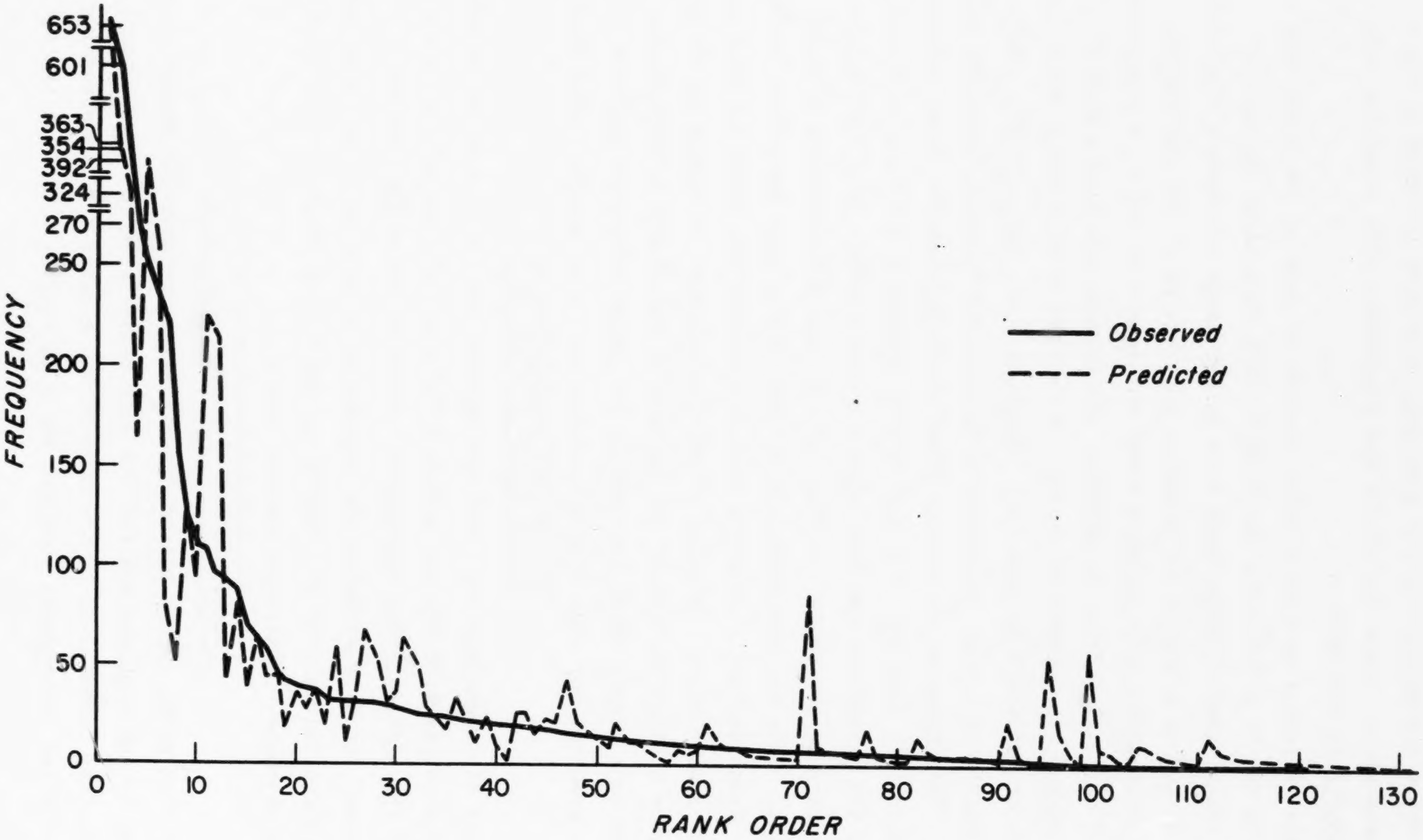

Fig. 6. Comparison of observed and predicted values for statement with verbs (entire corpus).

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TABLE 45

Comparison of Total Chi-Squares for all Grammars

Text	Noun-Phrase Grammar		Verb-Phrase Grammar		Verbal-Modifier Grammar		Grammar for Statements without Verbs		Interrogative Grammar		Grammar for Statements with Verbs	
	Chi-Sq.	DF	Chi-Sq.	DF	Chi-Sq.	DF	Chi-Sq.	DF	Chi-Sq.	DF	Chi-Sq.	DF
Ginn Pre-Primer	.5	1	4.9	2	-	-	-	-	-	-	-	-
Scott-Foresman Pre-Primer	2.3	0	41.4	1	-	-	-	-	-	-	-	-
Pre-Primers Combined	1.3	1	33.5	2	-	-	-	-	-	-	364.7	2
Ginn Primer	52.2	2	34.9	3	-	-	-	-	-	-	249.6	8
Scott-Foresman Primer	42.6	1	36.9	3	-	-	-	-	-	-	254.2	7
Primers Combined	95.3	2	69.1	4	-	-	-	-	-	-	478.3	26
Ginn Reader	81.5	2	72.9	3	-	-	-	-	-	-	406.3	25
Scott-Foresman Reader	177.5	2	12.9	3	-	-	-	-	-	-	206.0	15
Readers Combined	247.6	2	57.3	4	-	-	-	-	-	-	729.2	44
All Combined	316.8	2	159.1	4	9.6	5	13.0	3	52.3	2	1644.0	6.1

TABLE 46

Average "Chi-Squares" for all Grammars

Text	Noun-Phrase Grammar	Verb-Phrase Grammar	Verbal Modifier Grammar	Grammar for Statements without Verbs	Interrogative Grammar	Grammar for Statements with Verbs
Ginn Pre-Primer	.5	2.5	-	-	-	-
S-F Pre-Primer	-	41.4	-	-	-	-
Pre-Primers Combined	1.3	16.8	-	-	-	182.4
Ginn Primer	26.1	11.6	-	-	-	31.2
Scott-Foresman Primer	42.6	12.3	-	-	-	36.3
Primers Combined	47.7	17.3	-	-	-	18.4
Ginn Reader	40.8	24.3	-	-	-	16.3
Scott-Foresman Reader	88.8	4.3	-	-	-	13.7
Readers Combined	123.8	14.3	-	-	-	16.6
All Combined	158.4	39.8	1.9	4.3	26.2	27.0

the Scott-Foresman reader, the readers combined, and the corpus as a whole were significantly better than those of the noun-phrase grammar; the latter were equivalent to those given by the verb-phrase grammar.

All of the phrase-structure grammars presented in this chapter have been written to fit the corpus as nearly as possible. Only a few syntactic patterns which do not appear in the corpus but are generally considered grammatical can be generated by the grammars, and no provision has been made for unbounded embedding. In later uses, for example in making comparisons with oral speech, more general grammars might be preferable; in that case the same grammar would be used for both corpuses but different parameters would be estimated. Although more general constructions and unbounded embedding are possible in phrase-structure grammars, they are somewhat easier to conceptualize in categorial grammars. With this in mind, categorial grammars were written for the noun phrases and verb phrases; these are presented in the next chapter.

CHAPTER IV

CATEGORIAL GRAMMARS

For purposes of comparison, two categorial grammars, one for the noun phrases and one for the verb phrases, were constructed. It has been shown (Bar-Hillel, Gaifman & Shamir, 1960) that phrase-structure grammars and categorial grammars are equivalent in the range of languages they are capable of characterizing. Categorial grammars, while less easy to interpret than phrase-structure grammars, are more easily adapted to fit other corpuses (for example oral language) because they contain at most two rewrite rules. To adapt a categorial grammar to a new corpus the parameters must be reestimated and sometimes a few new categories must be added, but no new rewrite rules are needed.

The two rewrite rules for standard categorial grammars are:

1) $\alpha \rightarrow \alpha/\beta,\ \beta$

2) $\alpha \rightarrow \beta,\ \beta\backslash\alpha$

where α and β are categories. In writing a categorial grammar a finite number of primitive categories is selected; the primitive categories are usually taken to be "s" for sentence and "n" for noun. All primitive categories are categories, when when α and β are categories, $[\alpha/\beta]$ and $[a\backslash\beta]$ are categories--these are called derived categories. All words in the terminal vocabulary are classified into one or more of these categories.

A premise ("s" in standard categorial grammars) is chosen, and all grammatical types of utterances must be derivable from the premise, the rewrite rules, and the categories. Any utterance derivable in this way is considered grammatical, so the categories must be established so that all grammatical utterances, and only those, can be derived. The following example illustrates the method of derivation in a categorial grammar. Let "n" be the category for nouns and [n\s]/n be the category for transitive verbs. Then the categorial symbolism for the syntactical type (N+TV+N) is (n, [n\s]/n, n), and this can be generated as follows:

$s \rightarrow n, n\backslash s$ Rule 2, s for α, n for β
$n, n\backslash s \rightarrow n, [n\backslash s]/n, n$ Rule 1, [n\s] for α, n for β

Corresponding to the phrase structure grammars, parameters can be assigned to each choice point of the derivations, and the same statistical procedures for evaluating the grammars may be followed. In general four types of parameters are necessary for categorial grammars: a stopping parameter, a parameter for the choice of rule used, parameters denoting substitutions for β, and parameters denoting substitutions for α.

The first three parameter types represent unconditional probabilities and present no problem. The parameters for the choice of α, however, are conditional probabilities; they are conditional on the choices available from the previous application of the rule. In the example above, when rule 2 is applied, the only choice for α is "s" so the probability of that choice is one, when rule 1 is applied in the next step, there are two choices available for α, "n" and "n\s", and the probability of choosing "s" at this point is zero. In this example three parameters for α are needed: P[s for α given s], P[n for α given n, n\s], and P[n\s for α given n, n\s]; clearly the first probability is one and the sum of the last two probabilities is one. Under this system, a new set of α parameters is required each time a new set of choices is available. Some simplification can be achieved by considering the number of the choice instead of the choice itself. In the example above the required parameters would be: P[first choice given one choice], P[first choice given two choices], and P[second choice given two choices]; again the first probability is equal to one and the sum of the last two is one. When the number of the choice is the basis for parameter assignment, the number of necessary sets of α parameters is equal to the maximum number of times the rule is applied in any derivation of the grammar. If the grammar provides for an infinite number of rule applications, a decision could be made to stop when the probability of syntactical patterns reached a certain level close to zero; the maximum number of rule applications would then be finite. In the noun-phrase and verb-phrase grammars of this chapter, no choice of α is available, so the problem of conditional parameters does not arise.

Categorial Grammar for Noun Phrases

The categorial grammar for noun phrases is summarized in Table 47, and the derivations and theoretical probabilities are given in Table 48.

Insert Tables 47 and 48 about here

As can be seen from the derivations, only one rewrite rule is required for the noun-phrase grammar, so no parameter is necessary for the choice of the rewrite rule. The only choice made for α and β is "n", so no parameters are required for these choices either.

Three premises have been selected, "n", "p", and "g", but derivations are permitted from only the first of these. This is a deviation from standard categorial grammars in which only one premise is chosen and all derivations are made from the one premise. But such a deviation was necessary to correspond to the phrase-structure grammar in not allowing adjectives and articles to precede pronouns and proper nouns. Three parameters were required for the three premises; A_1 is the probability of choosing "n" for the premise, A_2 is the probability of choosing "p", and A_3 is the probability of choosing "g".

The optional transformation requires one (free) parameter; T_1 is the probability of choosing an article and $T_2 = 1-T_1$ is the probability of not choosing an article. This method of generating types such as (T+A+N) as well as (A+N) was the simplest which could be found. Other means, such as classifying articles as adjectives, generated phrases with the article between the adjective(s) and noun (for example, "red and yellow the ball" instead of "the red and yellow ball") as well as the desired syntactical types. As Table 47 shows, the same obligatory transformations used for the phrase-structure grammars are used here.

The variable "S_1" was chosen for the stopping parameter; this is a binomial parameter, $\binom{N}{x} S_1^{\,x}(1-S_1)^{N-x}$, where x is the number of times the rewrite rule was applied and "N" is chosen to be some number greater than

TABLE 47

The Categorial Grammar for Noun Phrases

Rewrite rule: $\alpha \rightarrow \alpha/\beta, \beta$

Premises from which derivations are possible: n

Premises from which no derivations are possible: p, g

Primitive categories: n

Categories:

n	(noun)
g	(proper noun)
p	(pronoun)
t	(article)
n/n	(adjective)

Obligatory transformations:

a) If "n" is "something", $n/n, n \rightarrow n, n/n$
b) If "n/n" is "what" or "all", $t, n/n, n \rightarrow n/n, t, n$
c) If "n/n_1" is "what" or "all", $t, n/n, n/n_2, n \rightarrow n/n_1, t, n/n_2, n$

Optional transformation: Any statement derivable from "n" may begin with an article, "t".

Parameters:
A_1-A_3, premise choice parameters
S_1-S_2, stopping parameter
T_1-T_2, optional transformation parameter

TABLE 48

Derivations from the Categorial Grammar for Noun Phrases

Type	Derivation	Theoretical Probability
P	g	A_2
G	g	A_3
N	n	$A_1\binom{N}{0}S_1{}^0S_2{}^NT_2$
A+N	$n \rightarrow n/n, n$	$A_1\binom{N}{1}S_1{}^1S_2{}^{N-1}T_2$
A+A+N	$n \rightarrow n/n, n \rightarrow n/n, n/n, n$	$A_1\binom{N}{2}S_1{}^2S_2{}^{N-2}T_2$
T+N	n + transformation	$A_1\binom{N}{0}S_1{}^0S_2{}^NT_1$
T+A+N	$n \rightarrow n/n, n$ + transformation	$A_1\binom{N}{1}S_1{}^1S_2{}^{N-1}T_1$
T+A+A+N	$n \rightarrow n/n, n \rightarrow n/n, n/n, n$ + transformation	$A_1\binom{N}{2}S_1{}^2S_2{}^{N-2}T_1$
A+A+A+N	$n \rightarrow n/n, n \rightarrow n/n, n/n, n \rightarrow n/n, n/n, n/n, n$	$A_1\binom{N}{3}S_1{}^3S_2{}^{N-3}T_2$

the maximum number of times the rule must be applied to generate all observed syntactical types. This a priori choice of "N" is not entirely satisfactory, but as will be seen in a later discussion of chi-square contributions and total chi-squares, within a certain range the choice does not have a significant effect on the parameter estimation. If "S_1" is estimated separately for types formed according to the number of times the rule was applied, "S_1" is a maximum-likelihood estimate as shown in the following derivation for N = 6, the value used in the application of the maximum-likelihood procedures as explained in Chapter III.

Type	Frequency	Probability
1	$K_1 = f_N + f_{T+N}$	$(1-S_1)^6$
2	$K_2 = f_{A+N} + f_{T+A+N}$	$6(1-S_1)^5(S_1)$
3	$K_3 = f_{A+A+N} + f_{T+A+A+N}$	$15(1-S_1)^4(S_1)^2$
4	$K_4 = f_{A+A+A+N}$	$20(1-S_1)^3(S_1)^3$
5	$K_5 = 0$	$15(1-S_1)^2(S_1)^4$
6	$K_6 = 0$	$6(1-S_1)(S_1)^5$
7	$K_7 = 0$	$S_1^{\ 6}$

$$L = [(1-S_1)^6]^{K_1} [6(1-S_1)^5 S_1]^{K_2} [15(1-S_1)^4 S_1^{\ 2}]^{K_3} [20(1-S_1)^3 S_1^{\ 3}]^{K_4}$$

$$\log L = K_1 \log[(1-S_1)^6] + K_2 \log[6(1-S_1)^5 S_1] + K_3 \log[15(1-S_1)^4 S_1^{\ 2}] + K_4 \log[20(1-S_1)^3 S_1^{\ 3}]$$

$$\frac{\partial \log L}{\partial S_1} = \frac{-6K_1}{1-S_1} + \frac{K_2}{S_1} - \frac{5K_2}{1-S_1} + \frac{2K_3}{S_1} - \frac{4K_3}{1-S_1} + \frac{3K_4}{S_1} - \frac{3K_4}{1-S_1}$$

Setting the derivative equal to zero and solving:

$$S_1 = \frac{K_2 + 2K_3 + 3K_4}{6K_1 + 6K_2 + 6K_3 + 6K_4}$$

Using the observed frequencies for the corpus as a whole (Table 50), $S_1 = .1054$. And this is the estimate obtained when the maximum-likelihood estimation procedures explained in Chapter III are applied. (Table 49)

Insert Tables 49 and 50 about here

TABLE 49

Maximum Likelihood Estimates for each Section of the Corpus for the Categorial Grammar for Noun Phrases

Parameter	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined	All Combined N=5	All Combined N=7	All Combined N=8
A_1	.3731	.1726	.2798	.3912	.3225	.3589	.4755	.5021	.4878	.4194	.4194	.4194	.4194
A_2	.2979	.6309	.4529	.4369	.5290	.4803	.3710	.3761	.3733	.4171	.4171	.4171	.4171
A_3	.3290	.1964	.2673	.1719	.1484	.1608	.1535	.1218	.1389	.1635	.1635	.1635	.1635
S_1	.0683	.0805	.0718	.1206	.1182	.1196	.1059	.1029	.1045	.1054	.1264	.0903	.0790
S_2	.9317	.9195	.9282	.8794	.8818	.8804	.8941	.8971	.8955	.8946	.8736	.9097	.9210
T_1	.6250	.4741	.5817	.5668	.5418	.5562	.6041	.4575	.5343	.5445	.5445	.5445	.5445
T_2	.3750	.5259	.4183	.4332	.4582	.4438	.3959	.5425	.4657	.4555	.4555	.4555	.4555

TABLE 50

Observed and Expected Frequencies, Chi-Square Contributions, and Total Chi-Squares for each Section of the Corpus for the Categorial Grammar for Noun Phrases

GINN PRE-PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
230	230.0	.0	P
254	254.0	.0	G
76	70.6	.4	N
23	31.1	2.1	A+N
8	5.7	.9	A+A+N
121	117.7	.1	T+N
42	51.8	1.8	T+A+N
17	9.5	5.9	T+A+A+N
1	.6		A+A+A+N
1	1.6		RESIDUAL
772	772.0	11.3	TOTAL
		3	DEGREES OF FREEDOM

SCOTT-FORESMAN PRE-PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
424	424.0	.0	P
132	132.0	.0	G
33	36.9	.4	N
24	19.4	1.1	A+N
4	4.2		A+A+N
36	33.2	.2	T+N
14	17.5	.7	T+A+N
5	3.8		T+A+A+N
9	8.1	.1	EXPECTED FREQ. LESS THAN 5.0
0	.5		A+A+A+N
0	1.0		RESIDUAL
672	672.0	2.5	TOTAL
		2	DEGREES OF FREEDOM

TABLE 50 (continued)

```
             PRE-PRIMERS COMBINED

    OBSERV.   EXPECT.   CHI**2  SOURCE

       654     654.0       .0  P
       386     386.0       .0  G
       109     108.1       .0  N
        47      50.2       .2  A+N
        12       9.7       .5  A+A+N
       157     150.3       .3  T+N
        56      69.7      2.7  T+A+N
        22      13.5      5.4  T+A+A+N
         1       1.0           A+A+A+N

         1       2.5           RESIDUAL

      1444    1444.0      9.1  TOTAL

                          3    DEGREES OF FREEDOM
```

```
             GINN PRIMER

    OBSERV.   EXPECT.   CHI**2  SOURCE

       727     727.0       .0  P
       286     286.0       .0  G
        86     130.4     15.1  N
       123     107.3      2.3  A+N
        56      36.8     10.0  A+A+N
       227     170.7     18.6  T+N
        99     140.4     12.2  T+A+N
        43      48.1       .5  T+A+A+N
        17       6.7     15.7  A+A+A+N

         0      10.5     10.5  RESIDUAL

      1664    1664.0     85.0  TOTAL

                          5    DEGREES OF FREEDOM
```

TABLE 50 (continued)

```
                SCOTT-FORESMAN PRIMER

      OBSERV.  EXPECT.  CHI**2  SOURCE

         784     784.0      .0  P
         220     220.0      .0  G
          63     103.0    15.5  N
         110      82.8     8.9  A+N
          43      27.7     8.4  A+A+N
         153     121.8     8.0  T+N
          78      97.9     4.1  T+A+N
          28      32.8      .7  T+A+A+N
           3       5.0          A+A+A+N

           3      12.0     6.7  RESIDUAL

        1482    1482.0    52.3  TOTAL

                             4  DEGREES OF FREEDOM
```

```
                PRIMERS COMBINED

      OBSERV.  EXPECT.  CHI**2  SOURCE

        1511    1511.0      .0  P
         506     506.0      .0  G
         149     233.3    30.5  N
         233     190.1     9.7  A+N
          99      64.6    18.4  A+A+N
         380     292.5    26.2  T+N
         177     238.3    15.8  T+A+N
          71      80.9     1.2  T+A+A+N
          20      11.7     5.9  A+A+A+N

           0      17.5    17.5  RESIDUAL

        3146    3146.0   125.1  TOTAL

                             5  DEGREES OF FREEDOM
```

TABLE 50 (continued)

GINN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

  1143   1143.0      .0   P
   473    473.0      .0   G
   215    296.3    22.3   N
   238    210.6     3.6   A+N
   103     62.4    26.5   A+A+N
   556    452.1    23.9   T+N
   243    321.3    19.1   T+A+N
    86     95.2      .9   T+A+A+N
    24      9.9    20.3   A+A+A+N

     0     17.4    17.4   RESIDUAL

  3081   3081.0   133.9   TOTAL

                      5   DEGREES OF FREEDOM
```

SCOTT-FORESMAN READER

```
OBSERV.  EXPECT.  CHI**2  SOURCE

   997    997.0      .0   P
   323    323.0      .0   G
   239    376.3    50.1   N
   370    259.0    47.5   A+N
    97     74.3     6.9   A+A+N
   430    317.4    40.0   T+N
   148    218.5    22.7   T+A+N
    31     62.7    16.0   T+A+A+N
    16     11.4     1.9   A+A+A+N

     0     11.4    11.4   RESIDUAL

  2651   2651.0   196.6   TOTAL

                      5   DEGREES OF FREEDOM
```

TABLE 50 (continued)

```
                READERS COMBINED

     OBSERV.  EXPECT.  CHI**2  SOURCE

       2140   2140.0      .0   P
        796    796.0      .0   G
        454    671.5    70.4   N
        608    470.1    40.4   A+N
        200    137.1    28.8   A+A+N
        986    770.5    60.3   T+N
        391    539.4    40.8   T+A+N
        117    157.4    10.4   T+A+A+N
         40     21.3    16.3   A+A+A+N

          0     28.6    28.6   RESIDUAL

       5732   5732.0   296.1   TOTAL

                          5    DEGREES OF FREEDOM
```

```
                ALL COMBINED

     OBSERV.  EXPECT.  CHI**2  SOURCE

       4305   4305.0      .0   P
       1688   1688.0      .0   G
        712   1011.0    88.4   N
        888    714.5    42.1   A+N
        311    210.4    48.1   A+A+N
       1523   1208.4    81.9   T+N
        624    854.0    61.9   T+A+N
        210    251.5     6.8   T+A+A+N
         61     33.0    23.7   A+A+A+N

          0     46.2    46.2   RESIDUAL

      10322   10322    399.3   TOTAL

                          5    DEGREES OF FREEDOM
```

TABLE 50 (continued)

```
                ALL COMBINED (N=5)

 OBSERV.  EXPECT.  CHI**2  SOURCE

  4305    4305.0      .0   P
  1688    1688.0      .0   G
   712    1003.1    84.5   N
   888     726.0    36.1   A+N
   311     210.2    48.4   A+A+N
  1523    1198.9    87.6   T+N
   624     867.7    68.5   T+A+N
   210     251.2     6.8   T+A+A+N
    61      30.4    30.7   A+A+A+N

     0      41.4    41.4   RESIDUAL

 10322   10322     403.9   TOTAL

                   5       DEGREES OF FREEDOM
```

```
                ALL COMBINED (N=7)

 OBSERV.  EXPECT.  CHI**2  SOURCE

  4305    4305.0      .0   P
  1688    1688.0      .0   G
   712    1016.5    91.2   N
   888     706.5    46.6   A+N
   311     210.5    48.0   A+A+N
  1523    1215.0    78.1   T+N
   624     844.4    57.5   T+A+N
   210     251.5     6.9   T+A+A+N
    61      34.8    19.7   A+A+A+N

     0      49.6    49.6   RESIDUAL

 10322   10322     397.7   TOTAL

                   5       DEGREES OF FREEDOM
```

TABLE 50 (continued)

ALL COMBINED (N=8)

OBSERV.	EXPECT.	CHI**2	SOURCE
4305	4305.0	.0	P
1688	1688.0	.0	G
712	1020.6	93.3	N
888	700.6	50.1	A+N
311	210.4	48.1	A+A+N
1523	1219.9	75.3	T+N
624	837.4	54.4	T+A+N
210	251.5	6.9	T+A+A+N
61	36.1	17.1	A+A+A+N
0	52.2	52.2	RESIDUAL
10322	10322	397.5	TOTAL
		5	DEGREES OF FREEDOM

If S_1 had been chosen to be a geometric distribution, no a priori choices would have been necessary. This distribution was effective in the work of Suppes (1970), but it would provide a poor fit in this case. If the geometric distribution had been used here, the parameter S_1 would have appeared in every theoretical probability involving "N", and whenever one or more adjectives were included, a corresponding number of $S_2 = 1-S_1$ terms would have appeared in the probability. The probability of type (N), for example, would have been: $(A_1)(S_1)(1-T_1)$ and the probability of type (A+N) would have been: $(A_1)(1-S_1)(S_1)(1-T_1)$. Thus the grammar would always predict a greater number of (N) types than (A+N) types, a greater number of (A+N) types than (A+A+N) types, etc. But the observed data did not show this trend. The Poisson distribution would have fit the stopping date in a manner similar to the binomial distribution and would not have involved an a priori choice; but the remaining statistical calculations would have been much more complicated, and for a first approximation this was not deemed necessary.

The categorial grammar for noun phrases generates the same types as the phrase-structure grammar, so the percents of the corpus accounted for by the categorial grammar are the same as those shown in Table 13. However, the stopping parameter allows the categorial grammar to generate seven types which are not found in the corpus. The stopping parameter allows the rule to be applied six times; thus all types from (N) to (A+A+A+A+A+A+N) and from (T+N) to (T+A+A+A+A+A+A+N) are possible, although the probabilities of the longer types are small. The grammar generates nine observed types and the seven unobserved types which are placed in one cell; four parameters are used so without further collapsing due to low predicted frequencies, the model allows five degrees of freedom.

Tables 49 and 50 show the maximum-likelihood estimates and the chi-square analysis for this grammar; in the maximum-likelihood calculations 6 was used for N unless otherwise stated. On Table 50 the column labeled "residual" includes the expected frequencies for types generated but not observed as well as any remaining uncollapsed types and round-off errors. The contributions from unlisted types is substantial but never as large as the largest contribution from the observed types.

Table 50 shows that for different sections of the corpus the source of large chi-square contributions varies. The contribution from type (N) is usually, but not always, the largest, and no other pattern is evident. For the phrase-structure grammar, on the other hand, the contributions from types (N) and (T+N) were consistently the greatest.

The last four pages of Table 50 show the chi-squares for the corpus as a whole for different choices of "N", the number chosen in connection with the stopping parameter. It is apparent that the choice has little effect on the total chi-square or on the individual contributions; for N equal to 5, 6, 7, and 8, the total chi-square values are 403.9, 399.3, 397.7, and 397.5 respectively. Very large values of N would of course affect the chi-squares because these values of N would give very small probabilities to phrases of one to four words and large probabilities to the longer, unobserved types.

Table 51 presents a comparison of total chi-squares for each section of the corpus for the phrase-structure and categorial grammars.

Insert Table 51 about here

Because of the differing degrees of freedom, F-tests were used to compare the chi-squares; in this situation the independence assumption is violated, so the results must be considered only as approximations. However, no significant differences were apparent. While the grammars differ in their ability to predict particular phrase types (with the phrase-structure being more regular), the overall fit provided by each grammar is approximately the same. The similarity of the fit is further demonstrated by Figure 7 which shows the observed frequencies plotted against their rank order and the frequencies predicted by the phrase-structure and categorial grammars plotted at the rank of the corresponding observed frequencies.

Insert Figure 7 about here

Table 51 shows that the rank order of the total comparative chi-squares ("comparative chi-square" indicates that differences in degrees of freedom have been considered) from the Ginn primer to the entire corpus is the same for the phrase-structure and categorial grammars. In both the trend of

TABLE 51

Comparison of Total Chi-Squares for the Phrase-Structure and Categorial Grammars for Noun Phrases

Text	No. of Phrases Accounted For	Phrase-Structure Grammar		Categorial Grammar	
		Total Chi-square	Degrees of Freedom	Total Chi-square	Degrees of Freedom
Ginn Pre-Primer	772	.5	1	11.3	3
Scott-Foresman Pre-Primer	672	2.3	0	2.5	2
Pre-Primers Combined	1444	1.3	1	9.1	3
Ginn Primer	1664	52.2	2	85.0	5
Scott-Foresman Primer	1482	42.6	1	52.3	4
Primers Combined	3146	95.3	2	125.1	5
Ginn Reader	3081	81.5	2	133.9	5
Scott-Foresman Reader	2651	177.5	2	196.6	5
Readers Combined	5732	247.6	2	296.1	5
All Combined	10322	316.8	2	399.3	5

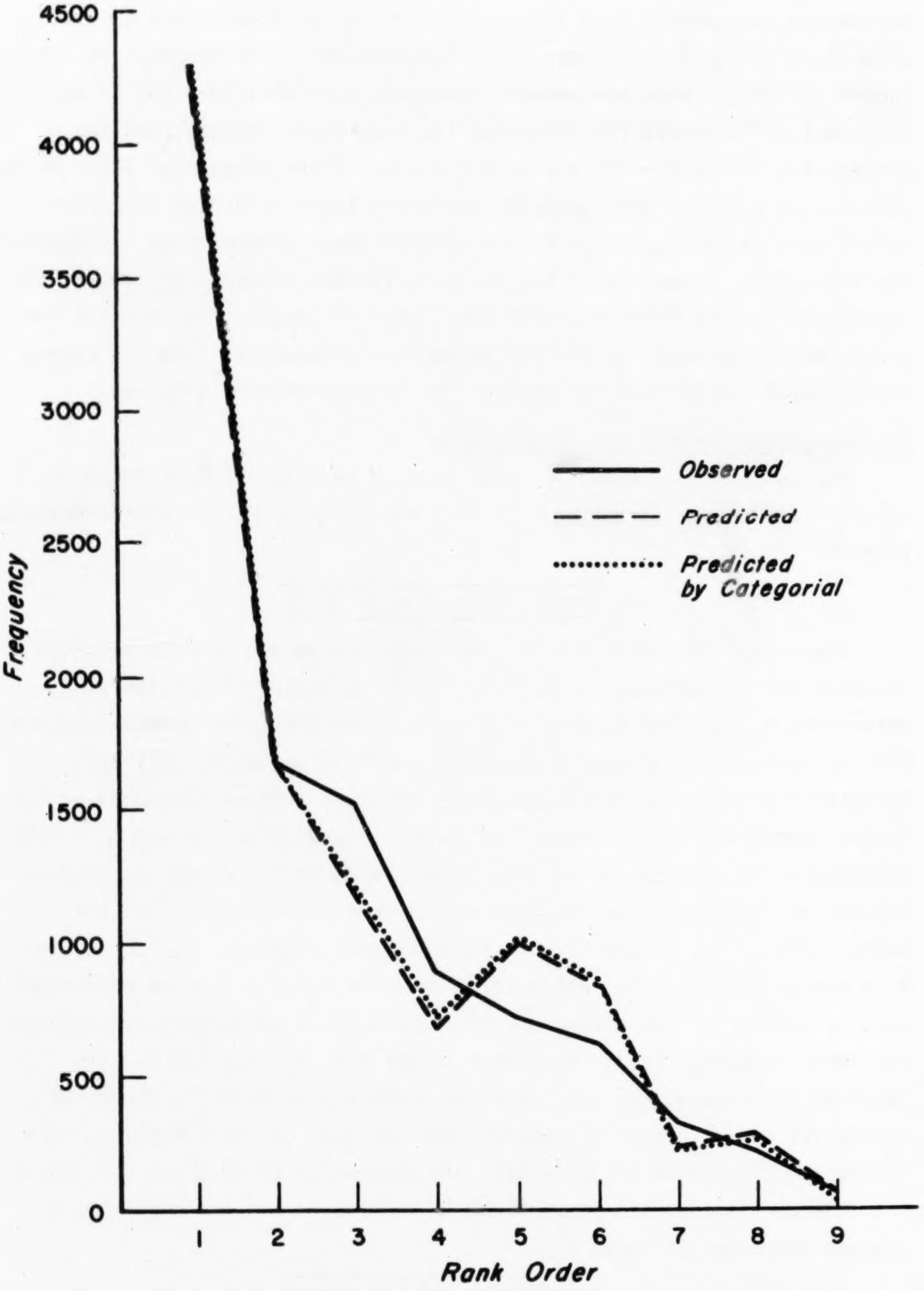

Fig. 7. Comparison of observed and predicted frequencies for phrase-structure and categorial grammars for noun phrases (entire corpus).

increasing chi-squares from the pre-primers to the primers and from the primers to the readers is apparent. For both the total comparative chi-square for the primers and readers combined is greater than the total comparative chi-square for either of the individual volumes, and the comparative chi-square for the entire corpus is the largest of all. It is interesting that for both grammars the pre-primers showed an exception to the rule of chi-squares for combinations being greater than chi-square for individual volumes. For the phrase-structure grammar the comparative chi-square for the Scott-Foresman pre-primer is larger than that for the pre-primers combined, and for the categorial grammar the Ginn pre-primer has a larger comparative chi-square than the pre-primers combined.

The Categorial Grammar for Verb Phrases

The categorial grammar for verb phrases is summarized in Table 52. The obligatory transformations are the same as those of the phrase-structure grammar.

Insert Table 52 about here

Again only one rewrite rule (this time the second rewrite rule) is required for the grammar, so no rule choice parameter is necessary. Parameters A_1, A_2, and A_3 have been used to designate the premise choices. For the verb phrase grammar a geometric stopping parameter, S_1, is acceptable because the frequency of the observed phrases decreases as the length increases; S_1 represents the probability of stopping and $S_2 = 1-S_1$ represents the probability of continuing. A geometric stopping parameter implies an infinite number of theoretical verb phrase types, but the probability of the longer types approaches zero rapidly. The choice for β is always "m", and the choice for α when the rule is applied more than once is always "m" and always the first term so no parameters are required for these choices. Thus, three free parameters, A_1, A_2, and S_1, are required for this model; nine observed types and an infinite number of unobserved types which are combined into one cell are generated, so when no further collapsing is necessary, six degrees of freedom are available.

The derivations and theoretical probabilities for the verb-phrase grammar are shown in Table 53.

Insert Table 53 about here

TABLE 52

The Categorial Grammar for Verb Phrases

Rewrite rule: $\alpha \rightarrow \beta, \beta\backslash\alpha$
Premises: s, s/n, s/[n/n]
Primitive category: m

Categories:		
	s	(intransitive verb)
	s/n	(transitive verb)
	s/[n/n]	(copulative verb)
	m\s	(infinitive form of intransitive verb)
	m\[s/n]	(infinitive form of transitive verb)
	m\[s/[n/n]]	(infinitive form of copulative verb)
	m	(modal)
	m\m	(negation)

Obligatory transformations:

1. If "m" is a form of "to be", $\begin{Bmatrix} m\backslash s \\ m\backslash[s/n] \\ m\backslash[s/[n/n]] \end{Bmatrix} \rightarrow \begin{Bmatrix} m\backslash s\text{+ing} \\ m\backslash s[s/n]\text{+ing} \\ m\backslash[s/[n/n]]\text{+ing} \end{Bmatrix}$

2a. If "m\s" is a form of "to be" or "to do" and "m" is a form of "to be" or "to do", m,m\m,m\s → s,m\m.

2b. If "s" is "will", "can", "may", "must", "shall", or "could", m,m\m, m\s → s,m\m.

3. If "m\[s/n]" is a form of "to be" and "m" is a form of "to be" or "to do", m,m\m,m\[s/n] → s/n,m\m.

4. If "m\[s/[n/n]]" is a form of "to be" and "m" is a form of "to be" or "to do", m,m\m,m\[s/[n/n]] → s/[n/n],m\m.

Parameters: A_1-A_3, premise choice parameters
S_1-S_2, stopping parameter

TABLE 53

Derivations from the Categorial Grammar for Verb Phrases

Type	Derivation	Theoretical Probability
IV	s	$A_1 \cdot S_1$
M+IV	$s \rightarrow m, m\backslash s$	$A_1 \cdot S_2 \cdot S_1$
M+-+IV	$s \rightarrow m, m\backslash s \rightarrow m, m\backslash m, m\backslash s$	$A_1 \cdot S_2^2 \cdot S_1$
TV	s/n	$A_2 \cdot S_1$
M+TV	$s/n \rightarrow m, m\backslash[s/n]$	$A_2 \cdot S_2 \cdot S_1$
M+-+TV	$s/n \rightarrow m, m\backslash[s/n] \rightarrow m, m\backslash m, m\backslash[s/n]$	$A_2 \cdot S_2^2 \cdot S_1$
CV	$s/[n/n]$	$A_3 \cdot S_1$
M+CV	$s/[n/n] \rightarrow m, m\backslash[s/[n/n]]$	$A_3 \cdot S_2 \cdot S_1$
M+-+CV	$s/[n/n] \rightarrow m, m\backslash[s/[n/n]] \rightarrow m, m\backslash m, m\backslash[s/[n/n]]$	$A_3 \cdot S_2^2 \cdot S_1$

The percent of verb phrases in each section of the corpus accounted for by this model are the same as those for the phrase-structure grammar and are given in Table 18. The maximum-likelihood estimates and the chi-square analysis are given in Tables 54 and 55.

Insert Tables 54 and 55 about here

As was stated earlier, the categorial grammar generates an infinite number of unobserved verb phrase types all of which have very small probabilities; the total probabilities of unobserved types in the pre-primers combined, primers combined, readers combined, and all combined are .004, .011, .010, and .009 respectively. The chi-square contributions from these types as well as contributions from any remaining uncollapsed types and round-off errors are shown in the row labeled "Residual" in Table 55. As in the noun-phrase grammar, these are substantial but far smaller than the largest contribution from an observed type.

Table 55 shows that except for the Ginn pre-primer (where the fit is consistently good) the largest contibutors to the total chi-squares are the (M+IV) and (M+-+TV) types. This reflects the problem faced by the phrase-structure grammar. The observed proportions of the use of modals and of modals plus negatives differ for transitive and intransitive verbs, but the parameter assignments do not reflect this difference.

A comparison of the phrase-structure and categorial grammars for verb phrases is presented in Table 56.

Insert Table 56 about here

Again F-tests were used to compare corresponding total chi-square values although the results are only approximations, and again no significant differences were apparent. The two kinds of grammars seem to provide equivalent fits to the observed data in each section of the corpus and in the corpus as a whole. Figure 8, which corresponds to Figure 7 for noun phrases, shows the similarity of the two fits.

Insert Figure 8 about here

TABLE 54

Maximum-likelihood Estimates for each Section of the Corpus for the Categorial Grammar for Verb Phrases

Parameter	Ginn Pre-Primer	S-F Pre-Primer	Pre-Primers Combined	Ginn Primer	S-F Primer	Primers Combined	Ginn Reader	S-F Reader	Readers Combined	All Combined
A_1	.5671	.5662	.5667	.4968	.4560	.4780	.5383	.4820	.5114	.5114
A_2	.4228	.4277	.4249	.4508	.5102	.4780	.4289	.4842	.4553	.4567
A_3	.0101	.0061	.0084	.0525	.0338	.0439	.0328	.0338	.0333	.0319
S_1	.8940	.7784	.8411	.7868	.7577	.7731	.7676	.8092	.7869	.7923
S_2	.1060	.2216	.1589	.2132	.2423	.2269	.2324	.1908	.2131	.2077

TABLE 55

Observed and Expected Frequencies, Chi-Square Contributions, and Total Chi-Squares for each Section of the Corpus for the Categorial Grammar for Verb Phrases

GINN PRE-PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
462	453.3	.2	IV
34	48.0	4.1	M+IV
11	5.1	6.9	M+-+IV
336	337.9	.0	TV
38	35.8	.1	M+TV
4	3.8		M+-+TV
7	8.0	.1	CV
0	.9		M+CV
2	.1		M+-+CV
6	5.8	.0	RESIDUAL
894	894.0	11.4	TOTAL
		3	DEGREES OF FREEDOM

SCOTT-FORESMAN PRE-PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
325	289.6	4.3	IV
30	64.2	18.2	M+IV
17	14.2	.5	M+-+IV
187	218.7	4.6	TV
68	48.5	7.9	M+TV
26	10.7	21.7	M+-+TV
1	3.1		CV
3	.7		M+CV
0	.2		M+-+CV
4	11.1	4.5	RESIDUAL
657	657.0	61.8	TOTAL
		3	DEGREES OF FREEDOM

TABLE 55 (continued)

PRE-PRIMERS COMBINED

OBSERV.	EXPECT.	CHI**2	SOURCE
787	739.3	3.1	IV
64	117.5	24.3	M+IV
28	18.7	4.7	M+-+IV
523	554.3	1.8	TV
106	88.1	3.6	M+TV
30	14.0	18.3	M+-+TV
8	10.9	.8	CV
3	1.7		M+CV
2	.3		M+-+CV
5	8.2	1.3	RESIDUAL
1551	1551.0	57.9	TOTAL
		4	DEGREES OF FREEDOM

GINN PRIMER

OBSERV.	EXPECT.	CHI**2	SOURCE
579	543.7	2.3	IV
75	115.9	14.4	M+IV
37	24.7	6.1	M+-+IV
455	493.3	3.0	TV
131	105.2	6.3	M+TV
41	22.4	15.4	M+-+TV
64	57.4	.8	CV
3	12.2	7.0	M+CV
6	2.6		M+-+CV
6	16.1	6.3	RESIDUAL
1391	1391.0	61.6	TOTAL
		5	DEGREES OF FREEDOM

00157

TABLE 55 (continued)

```
            SCOTT-FORESMAN PRIMER

   OBSERV.  EXPECT.  CHI**2  SOURCE

      459    408.4     6.3   IV
       53     99.0    21.3   M+IV
       27     24.0      .4   M+-+IV
      428    456.9     1.8   TV
       97    110.7     1.7   M+TV
       78     26.8    97.6   M+-+TV
       30     30.3      .0   CV
        2      7.3     3.9   M+CV
        8      1.8           M+-+CV

        8     18.6     6.0   RESIDUAL

     1182   1182.0   139.1   TOTAL

                        5    DEGREES OF FREEDOM
```

```
              PRIMERS COMBINED

  OBSERV.  EXPECT.  CHI**2  SOURCE

    1038    951.0     8.0   IV
     128    215.7    35.7   M+IV
      64     48.9     4.6   M+-+IV
     883    951.0     4.9   TV
     228    215.7      .7   M+TV
     119     48.9   100.3   M+-+TV
      94     87.4      .5   CV
       5     19.8    11.1   M+CV
      14      4.5           M+-+CV

      14     34.5    12.2   RESIDUAL

    2573   2573.0   177.9   TOTAL

                       5    DEGREES OF FREEDOM
```

TABLE 55 (continued)

```
                GINN READER

OBSERV.  EXPECT.  CHI**2  SOURCE
   901    831.4     5.8   IV
   121    193.2    27.0   M+IV
    61     44.9     5.8   M+-+IV
   585    662.5     9.1   TV
   199    153.9    13.2   M+TV
    79     35.8    52.3   M+-+TV
    60     50.7     1.7   CV
     3     11.8     6.5   M+CV
     3      2.7           M+-+CV

     3     28.0    22.3   RESIDUAL

  2012   2012.0   143.6   TOTAL

                      5   DEGREES OF FREEDOM
```

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          SCOTT-FORESMAN READER

OBSERV.  EXPECT.  CHI**2  SOURCE

   755    714.5     2.3   IV
    85    136.3    19.3   M+IV
    43     26.0    11.1   M+-+IV
   716    717.7       .0  TV
   109    137.0     5.7   M+TV
    62     26.1    49.2   M+-+TV
    42     50.2     1.3   CV
    12      9.6      .6   M+CV
     8      1.8           M+-+CV

     8     14.5     2.9   RESIDUAL

  1832   1832.0    92.5   TOTAL

                      5   DEGREES OF FREEDOM
```

TABLE 55 (continued)

```
                 READERS COMBINED

OBSERV.  EXPECT.  CHI**2  SOURCE

  1656   1547.0     7.7   IV
   206    329.7    46.4   M+IV
   104     70.3    16.2   M+-+IV
  1301   1377.1     4.2   TV
   308    293.5      .7   M+TV
   141     62.5    98.5   M+-+TV
   102    100.7      .0   CV
    15     21.5     1.9   M+CV
    11      4.6           M+-+CV

    11     41.8    22.7   RESIDUAL

  3844   3844.0   198.3   TOTAL

                    5     DEGREES OF FREEDOM
```

```
                 ALL COMBINED

OBSERV.  EXPECT.  CHI**2  SOURCE

  3481   3228.6    19.7   IV
   398    670.6   110.8   M+IV
   196    139.3    23.1   M+-+IV
  2707   2883.1    10.8   TV
   642    598.9     3.1   M+TV
   290    124.4   220.5   M+-+TV
   204    201.2      .0   CV
    23     41.8     8.5   M+CV
    27      8.7    38.6   M+-+CV

     0     71.4    71.4   RESIDUAL

  7968   7968.0   506.5   TOTAL

                    6     DEGREES OF FREEDOM
```

TABLE 56

Comparison of Total Chi-squares for the Phrase-Structure and Categorial Grammars for Verb Phrases

Text	No. of Phrases Accounted For	Phrase-Structure Grammar Total Chi-square	Phrase-Structure Grammar Degrees of Freedom	Categorial Grammar Total Chi-square	Categorial Grammar Degrees of Freedom
Ginn Pre-Primer	894	4.9	2	11.4	3
Scott-Foresman Pre-Primer	657	41.4	1	61.8	3
Pre-Primers Combined	1551	33.5	2	57.9	4
Ginn Primer	1391	34.9	3	61.6	5
Scott-Foresman Primer	1182	36.9	3	139.1	5
Primers Combined	2573	69.1	4	177.9	5
Ginn Reader	2012	72.9	3	143.6	5
Scott-Foresman Reader	1832	12.9	3	92.5	5
Readers Combined	3844	57.3	4	198.3	5
All Combined	7968	159.1	4	506.5	6

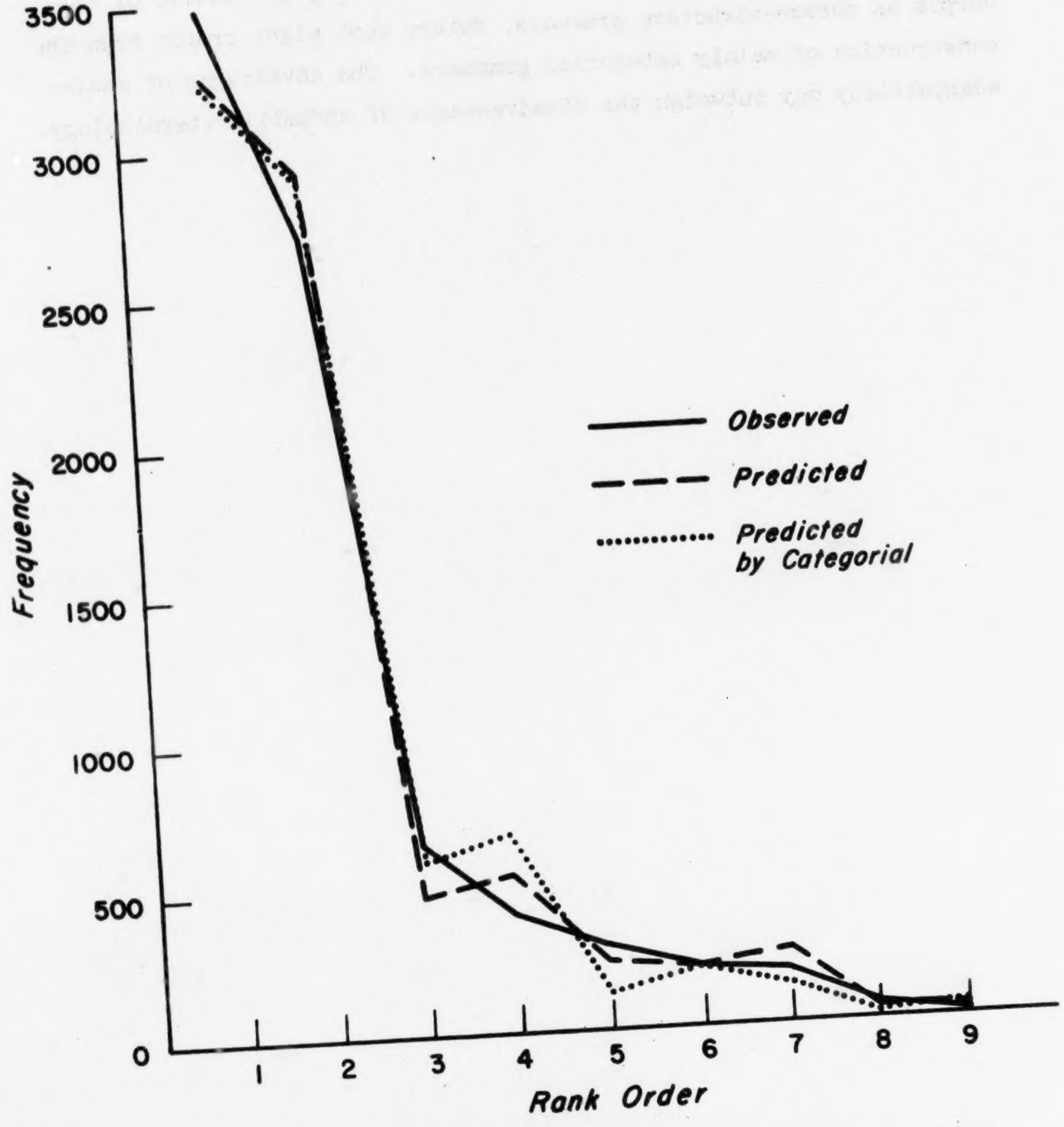

Fig. 8. Comparison of observed and predicted frequencies for phrase-structure and categorial grammars for verb phrases (entire corpus).

The two categorial grammars which have been presented in this chapter provide approximately the same degree of fit to the data as the corresponding phrase-structure grammars given in Chapter III. If categorial grammars can, as indicated by this work, be as representative of the corpus as phrase-structure grammars, future work might profit from the construction of mainly categorial grammars. The advantages of easier adaptability may outweigh the disadvantages of unfamiliar terminology.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study has provided a syntactical analysis of two widely used first grade readers--the Scott-Foresman series and the Ginn series. The analysis was presented in terms of six phrase-structure grammars, each of which provides a probabilistic description of the phrases it represents. The six grammars--a noun-phrase grammar, a verb-phrase grammar, a verbal-modifier grammar, a grammar for statements without verbs, an interrogative grammar, and a grammar for statements with verbs--were necessary because of the extremely large number of utterance types contained in the corpus. A single grammar containing all syntactic details would have had to account for many type frequencies which were too small for statistical analysis. For purposes of comparison categorial grammars were written for the noun phrases and the verb phrases.

The study has demonstrated a quantitative method for evaluating linguistic grammars. The method provides a theoretical framework to account for the utterances of the corpus and their frequencies of occurrence, and provides a quantitative measure for judging the fit of a grammar to a corpus and for comparing the fit of two different grammars to the same corpus. Parameters attached to the choice points of a grammar can be used to form the theoretical probability of [illegible] syntactical type derivable from the grammar. The parameters are estimated by methods of maximum-likelihood, and the estimated probabilities provide theoretical frequencies for each syntactical type. Chi-square tests are then used to determine the goodness-of-fit of the grammar to the corpus.

Both the Scott-Foresman and the Ginn first-grade reading series are divided into a pre-primer, a primer, and a first reader. All of the grammars accounted for a high percent of their respective phrases or utterances in each section of the corpus. The grammar for noun phrases, for example, accounted for 98.6 percent of the pre-primers, 98.2 percent of the primers, 98.0 percent of the readers, and 98.2 percent of the entire corpus; the respective percents of the grammar for statements with verbs were 91.2, 87.5, 81.8, and 85.5. Very few types not found in the corpus were generated by the phrase-structure grammars, and these had low probabilities; unobserved types were generated by the categorial grammars, and these too had very low probabilities.

Whenever the observed frequencies were sufficiently large, the analysis was performed on each section of each series and on the corresponding combined sections, as well as on the corpus as a whole. In each case the same grammar was used, but the parameters were reestimated, new theoretical type frequencies were obtained, and corresponding chi-square values were computed. For the noun-phrase grammars (both phrase-structure and categorial) the chi-square values increased from the pre-primers to the primers and from the primers to the readers indicating that these grammars provide the best fits at the lower reading leveles. A second trend for the noun-phrase grammars was larger chi-square values for the combined sections (e.g., for the Scott-Foresman and Ginn primers combined) than for either individual section. This reflects a difference in proportional noun-phrase frequencies in the two series. Neither of these trends was present in the verb-phrase grammars or in the grammar for statements with verbs; in these grammars there were no significant differences among sections of the corpus with the exception of an extremely poor fit of the statement grammar to the pre-primers combined. Individual section analyses were not possible for the other three grammars.

In general the grammars provided a good fit to the corpus. Large total chi-squares were generally composed of a few large contributions and many small contributions implying that overall the probabilistic framework was quite representative. However, in constructing the grammars a large number of parameters was used; the number of degrees of freedom was small relative to the size of the chi-squares, and some sort of fit would be expected. It is hoped that in further investigations grammars which require a smaller number of parameters will be written.

The best fit for the phrase-structure grammars was provided by the verbal-modifier grammar, and the fit of the grammar for statements without verbs was almost equivalent. The fit of the interrogative grammar and that of the verb-phrase grammar to their respective parts of the corpus were roughly equivalent and better than the fit of the noun-phrase grammar. The verb-phrase grammar provided a better fit than the noun-phrase grammar for all sections of the corpus, but the difference was significant only in the case of the Scott-Foresman reader and the readers combined. For the grammar for statements with verbs, the fits to the primers individually and combined and to the Ginn reader were not significantly different than those of the noun-phrase grammar for corresponding sections. The fit to the pre-primers combined was significantly worse; and the fits to the Scott-Foresman reader, the readers combined, and the corpus as a whole were significantly better than those given by the noun-phrase grammars; the latter were equivalent to those of the verb-phrase grammars.

The categorial grammars were approximately equivalent to the phrase-structure grammars in their ability to represent the corpus. For future work categorial grammars might be a better basis for analysis than phrase-structure grammars even though they involve less familiar terminology. Any work which involves the comparison of one corpus to another--child speech to child readers, for example--requires a grammar which is easily adaptable. To adapt a categorial grammar to a new corpus, a few new categories may be necessary, but no new rewrite rules are needed; while new parameters for category choices might be needed, the assignment of the basic rule choice and stopping parameters would be unchanged. In contrast, to adapt a phrase-structure grammar to a new corpus many of the rewrite rules themselves would have to be changed; this would involve a reassignment of parameters which, in turn, would make final comparisons more difficult.

This dissertation has made a contribution to the problem of finding an appropriate match of reading materials to the reader. Previous work Bormuth (1964); Ruddell (1964, 1965); Strickland (1963) has indicated a definite relationship between the ease of reading and comprehension to the similarity of written material and the spoken language of the reader. This study has demonstrated a method for a concise representation of syntactic patterns and their frequencies in a corpus and has suggested a quantitative analysis to indicate exactly how accurate the representation is. It has provided such a representation for two widely used first-grade readers, the Scott-Foresman series and the Ginn series. It is hoped that further investigation with special emphasis on reducing the number of parameters and including the most infrequent patterns will improve the analysis; this work should involve experimentation with other kinds of generative grammars as well as revisions of the grammars which have been used here. A later step is to similarly analyze the speech of first graders using these texts--some who are having reading difficulty and some who are not--to see what comparisons and what differences exist. The findings may indicate some changes in the reading material, particularly for those who are having trouble, which would increase the similarity of the sentence structure of the material to that of the children's speech.

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00171

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